3357
41

METEORITES

A DISSERTATION ON THEIR
ORIGIN PHENOMENA
CONSTITUTION
AND
CHEMICAL NATURE

By

Corydon B. ^{Powell} Karr

1878?

Introduction.

The study of meteorites embraces several fundamental questions of the physical history of the universe. Astronomy and Geology claim a like interest and relationship in them. On the one hand they are the only specimens of extra-terrestrial or cosmical bodies with which it is possible for us to have actual contact; or which can afford us any tangible ideas respecting the constitution of the bodies scattered through the celestial spaces. On the other hand, the more thorough our study of them the better we shall recognize the bearing which they may have on sundry branches of knowledge, and particularly the history of our

DSI

globe. Thus it is that meteorites constitute an essential as well as new chapter in geology.

In an elaborate series of experiments Daubree has sought to demonstrate by synthetic methods how meteorites have been formed. In 1868 he gave his results to the world. Since then he has continued his studies in that direction. Haidinger, Lawrence Smith, Greg Maskelyne and others have studied in the same field and in many respects have arrived at different conclusions.

Maskelyne proposed to call the study of meteorites the science of Aerolithics but the term has not been adopted. I have compared the different theories advanced to account for the origin of meteorites but I am compelled from absence of a logical demonstration to come to Prof Maskelyne's conclusion in regard to them namely, that we are not yet in a position to accept with certainty any hypothesis which has

been offered. The various hypotheses which suppose for them an origin in lunar volcanoes, or in our atmosphere, or again in a destroyed telluric satellite, or that would treat them as fragments of an original planet of which the asteroids are parts, or as masses ejected from the sun; all these hypotheses seem to be precluded more or less, by the known velocities, the retrograde motion so frequently characterizing meteors and meteorites, or else by the chemical conditions that, for instance are involved in the passage of the meteorite through the sun's chromosphere. Whether meteorites move in circumsolar orbits it is, with our present knowledge impossible to say, because we are not justified in founding ~~a~~ conclusion on a negative result.

I have devoted the most space in this dissertation to the studies growing out of the chemical relations which the ingredients of meteorites bear to each other. Dr Smith goes so far as to

say, that with our present modes of studying them, it is not necessary for us to know whether a piece of iron supposed to be meteoric has been seen to fall, for we are able to demonstrate its nature and authenticity by purely chemical means. I have drawn almost entirely upon the German literature of this subject for materials and have availed myself of the exhaustive works of Gustav Rose, Rammelsberg, Reichenbach, Haidinger and others. It would fill over a hundred pages to cite the literature which has been examined. I have thought not to complete P. A. Kesselmeier's catalogue from 1860 to 1878. Among the great collections of the world are the Vienna, the London, the Berlin, Prague, Paris, and the private collections of Bevil, Shepard, Greg, Reichenbach, Smith and others.

METEORITE of LANCE FRONT VIEW.
Fell July 23 1872 Canton St-Amand
Loir-et-Cher France

METEORITE OF LANCE REAR VIEW

ORIGIN OF FORMATION OF METEORITES

Various theories have at different times been proposed to account for the presence of meteorites, or aerolites. These theories may be classified into two great divisions

First, the terrestrial sources - the source or origin of these bodies being supposed to belong to our earth; and secondly; the cosmical sources, which derive their origin from beyond our earth.

These again may be divided into two sections or classes as follows.

I Terrestrial Sources

- 1 Volcanic - from the volcanoes of the earth
2. ATMOSPHERIC - from their supposed formation in the atmosphere of our earth

II COSMICAL SOURCES

- 1 LUNAR VOLCANIC - from the volcanoes of the moon
2. INTERPLANETARY SPACE - the planetary or asteroidal theory.

I will now review these different theories and endeavor to epitomize the results of scientific thinkers as far as possible.

De Luc endeavored to show that meteoric masses must be projected from terrestrial volcanoes, and in this view he was supported by Lichtenberg and others.

But this theory is objected to on many grounds and by some scientists it is wholly ignored, the facts which militate against this theory are,

- 1st The orbital motion of meteorites whose paths have been observed.
- 2nd. The velocity with which they travel.
- 3rd. The insignificant size and weight of stones which are known to have been expelled from volcanoes and as compared with the size and weight of meteoric irons
- 4th The crystallized state of many minerals and the net work of iron in meteoric irons which are formed in a state of fusion whose cooling has been of long duration and of a quiet nature whereas all terrestrial volcanic masses while fused are in a state of active ignition.
- 5th The absence of the phosphide of iron and nickel in any volcanic rock.

2. The atmospheric theory.

The chief exponent of this theory is Prof Shepard who in 1848 published it to the world but he no longer entertains these views although never publicly contradicted

He says - "The extra-terrestrial origin of meteoric stones and iron masses, seems likely to be more and more called in question with the advance in knowledge respecting such substances and as additions continue to be made to the connected sciences. Great electrical excitation is known to accompany volcanic eruptions which may reasonably be supposed to occasion some chemical changes in the volcanic ashes ejected; these being wafted by the ascensional force of the eruption into the regions of the magneto-polar influence, may there undergo a species of magnetic analysis. The most highly magnetic elements (iron, nickel, cobalt, chromium etc) or compounds in which these predominate, would thereby be separated, and become suspended in the form of metallic dust, forming those columnar clouds so often illuminated in auroral displays, and whose position conforms to the direction of the dipping needle.

20 7

While certain of the diamagnetic elements (or combinations of them) on the other hand, may under the control of the same force be collected into different masses, taking up a position at right-angles to the former, (which Faraday has shown to be the fact in respect to such bodies) and thus produce those more or less regular arches, transverse to the magnetic meridian, that are often recognized in the phenomena of the aurora borealis.

Any great disturbance of these forces maintaining these clouds of meteor dust like that produced by a magnetic storm might lead to the precipitation of portions of the matter thus suspended. If the disturbance was confined to the magnetic dust, iron masses would fall; if to the diamagnetic dust, a non-ferruginous stone; if it should extend to both classes simultaneously, a blending of the two characters would ensue in the precipitate, and a rain of ordinary meteoric stones

"The occasional raining of meteorites might therefore on such a theory, be as much expected, as the ordinary deposition of moisture from the atmosphere. The former would originate in a mechanical elevation of volcanic ashes and in matter swept into the air by tornadoes, the latter from simple evaporation. In the one case, the matter is upheld by magneto-electric force; in the other by the law of diffusion which regulates the blending of vapors and gases and by temperature. A precipitation of metallic and earthy matter would happen on any reduction of the magnetic tension; one of rain, hail, or snow, on a fall of temperature.

The materials of both originate in our earth

In the one instance they are elevated but to a short distance from its surface, while in the other, they appear to penetrate beyond its farthest limits, and possibly to enter the interplanetary space; in both cases however, they are destined, through the operation of invariable laws, to

returns to their original repository."

Both J. Lawrence Smith and R. P. Greg offer strong objections to this theory, I shall endeavor to combine their objections.

In speaking of Shepard's theory Dr John Alex. Smith an eminent English savant alludes to the puzzling fact of the great relative proportion of metallic falls which have been discovered in America, as compared with any other part of the known world, he says, it is very curious to observe in the New World, we have the greatest number of metallic falls, apparently in the neighborhood of the very locality where the magnetic force is described as being in a maximum in the Northern Hemisphere. The metallic falls of the Old World seem also to bear a relation to the other magnetic pole; though from its force of attraction being relatively weaker, it may be, the number of these metallic aerolites here is less and the concentration of them together would also appear to be less.

Professor Smith very ably says, First of all it must be proved that terrestrial volcanoes contain all the varieties of matter found in the composition of meteoric bodies; there is no doubt that many of the varieties are ejected from volcanoes etc., but then the principal one, nickeliferous iron has never in a single instance been found in the lava or other matter coming from volcanoes although frequently sought for.

The physical obstacles are a still more insuperable difficulty in adopting this theory. In the first place it is considered a physical impossibility for tornados or other currents of air to waft matter, however impalpable "beyond the farthest limits of the earth and possibly into interplanetary space." Again if magnetic and diamagnetic forces cause the particles to coalesce and form solid masses, by the cessation of those forces the bodies would crumble into powder.

Another strong physical objection to the theory is that as the consolidation of these masses

is expected to take place in "magneto-polar regions" their fall should only be in those portions of the earth, for like rain and hail to which the consolidation of these bodies are assimilated in this theory, they should fall perpendicularly or nearly so, from their points of condensation. And lastly (under the head of physical objections, how can bodies so formed be precipitated in such very oblique directions as many are known to have, and that too from East to West. The fall of a meteorite is usually preceded by an explosion and a scattering, rather than uniting, of fragments or bodies.

Humboldt in his *Cosmos* decidedly expresses the opinion that the nature of these meteoric stones, and the phenomena accompanying their fall are such as to preclude the idea of their having been condensed from minute matter or from a gaseous state, in a short-interval of time: he also states that meteoric masses kindle and become luminous at elevations

which must be supposed to be almost entirely deprived of air and frequently explode at great elevations.

The particles of iron and nickel supposed to be ejected from the volcano, must pass from the heated mouth of a crater, ascend through the oxygen of the atmosphere here without undergoing the slightest oxidation, for if there is any one thing which marks the meteorites more strongly than any other it is the freedom of the masses of iron from oxidation except on the surface. But a still more remarkable abstinence from oxidation would be the ascent of the particles of phosphorus to form of the Schreibersite traceable in so many meteorites.

La Grange Arago and Humboldt all agree in rejecting the atmospheric origin of meteorites.

II COSMICAL SOURCES

1. The Lunar Volcanic Theory.

This theory was proposed as early as 1660 by an Italian philosopher, Terzago, and advanced by Olbers in 1795, without any knowledge of its having been before proposed. It was sustained by Laplace and Berzelius, and the following distinguished mathematicians and philosophers: Biot, Brandes, Poisson, Lulliet, Arago, and Benzenberg and in modern times J. Lawrence Smith.

Some of the above astronomers abandoned the theory, among them Olbers and Arago. Sears & Walker on the periodical meteors of August and November makes the following remarks about Olbers's change of views "In 1836 Olbers, the original proposer of the theory of 1795, being firmly convinced of the correctness of Brandes's estimate of the relative velocity of meteors, renounces his selenic theory, and adopts the cosmical

theory as the only one which is adequate to explain the established facts before the public."

Dr Smith, ~~does not~~ ^{does not} enter upon all the points of plausibility of this assumed origin. He says "We shooting stars and meteoric stones the same class of bodies, it is natural to suppose that the fall of the latter would be most abundant when the former are most numerous. In other words the periodic occurrences of shooting stars ought to have been attended with the falling of one or more meteoric stones; whereas there is not an instance on record where these showers have been accompanied by other meteors. There is no proof that their velocities are of the same nature. The average velocity of shooting stars is $16\frac{1}{2}$ miles a second; not so with meteoric stones, their fall is rarely witnessed and no two observers being ever prepared to note the data requisite for calculating their

velocities, the difficulties in the way are so great - that we cannot arrive at an accurate knowledge of their velocities. and he comes to the conclusion, that as the most correct observations have never given a velocity of less than nine miles a second to a shooting star, it is reasonable to suppose that none have ever entered our atmosphere, or what perhaps is still more reasonable, that the matter of which they are composed is as subtle as that of Encke's comet, and any contact with even the uppermost limit of the atmosphere, destroys their ~~force~~ velocity and disperses the matter of which they are composed.

The following propositions which Dr Smith believes to corroborate his theory are

1st - That all meteoric masses have a community of origin

2nd - At one period they formed parts of some large body

3rd. They have all been subject to a more or less prolonged igneous action corresponding to that of terrestrial volcanoes.

4th That their source must be deficient in oxygen.

5th. That their average specific gravity is about that of the moon.

It would appear far more singular that these bodies should have been formed separately from each other than that they should have at one time or another constituted parts of the same body; and from the character of their formation, that body should have been of great dimensions. No one disputes the assertion that the minerals which compose the meteoric stones, bear a great resemblance to those of terrestrial volcanoes.

They have however sufficient difference in association to establish that although igneous they are extra-terrestrial. The source must also be deficient in oxygen either

in a gaseous condition or combined as water. The reasons for so thinking are based upon the existence of metallic iron in meteorites; a metal so oxidizable, that in its terrestrial associations, is almost always found combined with oxygen and rarely in its metallic state (supposed meteoric or native iron of Ovilak, Greenland)

Prof J. L. Smith further says, It cannot be doubted from what we know of the moon that it is in all likelihood constituted of such matter as compose meteoric stones, and that its appearance indicates volcanic action, which when compared with the combined volcanic action on our globe, is like contrasting *Htna* with an ordinary forge; so great is the difference. The results of volcanic throws and outbursts of lava are seen, for which we seek in vain anything but a faint representation on the surface of our earth. It is clearly established

that there is neither atmosphere nor water on the surface of that body and consequently no oxygen in those conditions which would preclude the existence of metallic iron.

The density of the moon is about 3.62 and of meteorites (the average) is 3.00.

The chemical composition is insisted upon by Berzelius and others as a strong ground in favor of their lunar origin. In the memoir on Periodic meteors Walker states "The chemical objection is not very weighty, for we may as well suppose a uniformity of constituents in chemical as in lunar substances." Prof Smith dissents from this, because we are only acquainted with the materials of but two bodies, those of the earth and of meteorites, and their dissimilarity is an evidence of their belonging to different spheres.

Laplace's view of the matter was connected with present volcanic action in the moon, but there is every reason to believe that all such action has long since ceased in the moon.

1770
This however, does not invalidate this theory in the least, for the force of projection and modified attraction to which the detached masses were subjected, only gave them new and independent orbits ~~at~~ around the earth, that may endure for a great length of time before coming in contact with the earth. The various astronomers cited concur in the opinion that a body projected from the moon with a velocity of about eight thousand feet per second would go beyond the mutual point of attraction between the earth and moon, and already having an orbital velocity may become a satellite of the earth with a modified orbit.

The important question then, for consideration is, the force requisite to produce this velocity. The force exercised in terrestrial volcanoes varies according to Dr Peters who made observations on Aetna, the velocity of some of the stones was 1250 feet-a second, and observations made on the peak of Teneriff gave 3000 feet a second.

Assuming however, the former velocity to be the maximum of terrestrial volcanic effects, the velocity with which the bodies started (stones with a specific gravity of about 3.00) must have exceeded 2000 feet a second to permit of an absorbed velocity of 1250 feet through the denser portions of our atmosphere. Now suppose the force of the extinct volcanoes of the moon to have equalled that of Aetna, the force would have been more than sufficient to have projected masses of matter at a velocity exceeding 8000 ft a second; for the resistance to be overcome by the projectile force, is the attractive force of the moon, which is from five to six times less than that of the earth, so that the same projectile force in the two bodies would produce vastly greater velocities on the moon than on the earth, discarding of course atmospheric resistance, of which there is none in the moon.

In answer to this plausible theory Greg (R.P.)

remarks "It would appear to me more reasonable and consistent with our ideas of terrestrial volcanoes to suppose, that the total absence of water and atmosphere in the moon is favorable to the notion that volcanic action there is of a less violent and explosive character than on the earth."

I have explored the literature of volcanoes with a view to obtain the most advanced, liberal and enlightened notions regarding their origin and energy, and I think the combined views of J. D. Dana and Robert Mallet F. R. S. are the most-satisfactory. Dana sustains Prévost's theory that the force of eruption engaged is chiefly pressure from the expansion of vaporizable material rising with the lava. Besides this there is the hydrostatic pressure of the liquid column raised in the conduit through the expanding vapors. Mallet states that the access of water to the points of fusion determines volcanic eruption and I would like to make the following suggestion which

may be worthy of consideration; that as it is admitted, the absence of moisture or atmosphere on the surface of the moon and the absorption by the mass of its former sea and water beds to hydrate the rocks, that therefore the absence of water has caused the volcanoes to become extinct or nearly so, and thus if water is absent and no possibility of the generation of steam, what volcanic action does occur must do so from the two other causes adduced and from the first cause or lateral pressure ^{the crust} the eruptions cannot be violent, from the second cause, the hydrostatic pressure of pent up vapors, we can safely affirm that as soon as these vapors find an exit, the tension decreases and as the pressure accumulates by degrees, so must be the relief gradual rather than violent, and unless violent the projectile cannot be thrown to any great distance.

Dr Smith says however -

But doubtless, were the truth of the matter known, the projectile force of lunar volcanoes far exceeded that of any terrestrial volcanoes extinct or recent, and this we infer from the enormous craters of elevation to be seen upon its surface, and their great elevation above the general surface of the moon, with their borders thousands of feet above their center. all of which point to the immense internal force required to ~~melt~~ elevate the melted lava that must have at one time poured from their sides.

But Prof Dana argues that the great breadth of the craters is no evidence of great projectile force, the pits being regarded as boiling craters where force for lofty projection could not accumulate.

Greg remarks that - doubtless volcanic action has been highly developed at the surface of the moon, but in the absence of all water, we may conclude that lava floods have rather been emitted from her volcanoes, than discharges of stones and ashes.

It will be seen that Mr Greg's view is a

certain extent agrees with mine. Mr. Gey has various objections to the lunar origin and I will proceed to give them.

It is still considered by some astronomers that the moon is not altogether without an atmosphere; though that be of small extent, it may nevertheless be rich in oxygen. It would be difficult to suppose that the extensive volcanic action which has evidently taken place in the moon, could have been exerted or maintained without the presence of oxygen; and if we admit that aerolites come from that body, we must necessarily concede there the existence of oxygen, since most aerolites contain a considerable quantity of silica, magnesia, and alumina. The scarcity of oxygen where meteorites originate does not prove they proceed from the moon but merely that they come from some place deficient in oxygen. If meteoric masses of native iron really come from the moon, their non oxidation might arise more from the

absence of aqueous vapors than from an absence or deficiency of oxygen. Even admitting that some aerolites have proceeded from lunar volcanoes, and that they have all the characters of erupted volcanic rocks, it by no means follows that all meteoric masses, even iron ones, also come from the same source or place, for in many aerolites and meteoric irons there is little if anything of a volcanic character.

We cannot reasonably suppose that lunar volcanoes have ejected enormous masses of iron, whether in a pure or oxydized state, when iron occurs in such small quantity and so rarely as the product of terrestrial volcanoes, and then most frequently deposited by sublimation. The density of the moon is 3.6 (Smith) while that of the earth is 5.6; this renders it still more improbable that substances of greater density, as the metals, are more abundantly ejected from the volcanoes in the moon, than from those of the earth, the

latter body having the greater average density. It is evident that no ordinary initial ~~velocity~~ volcanic force could ever project such ponderous masses (those of Surango and Rio de la Plata 10 to 20 lbs) beyond the point or limit of the mutual attractions of the moon and earth. This militates against Dr Smith's first proposition. Dr Daubny states that the stones which overwhelmed Pompeii did not weigh more than 8 lbs. It would surely make a material difference in our calculations whether a mass projected from a volcano in the moon weighed 30 lbs or 30000 lbs.

Dr Smith has made some interesting experiments to prove the fallacy of judging of the actual size of meteors by their apparent size and I will give them when considering the phenomena connected with their fall.

Dr Smith says that no meteorite is known of any very great size, none larger than the granite balls to be found at the Dardanelles.

It is not strictly true that no meteorite known is of any great size, for one or two of the larger meteoric iron masses have been described by travellers as being 7 feet in length and weighing 15 tons. It would be improbable that such a mass could be projected beyond the mouth of either a lunar or terrestrial volcano much less reach a height of several thousand feet.

The following calculations (Mr Greg's) will show that a mass of iron having a spherical form and weighing 20000 lbs.; could not ^{reasonably} have a greater velocity than 372 feet in a second if projected from a lunar volcano. The calculations are based on the following premises,

A stone having 5.6 inches in diameter, with a density of 3.0 and weighing 10 lbs., is assumed to be projected from a lunar volcano at the rate of 9000 feet in a second i.e. with a

velocity more than sufficient, according to Dr Smith and others, to allow it to pass the limits of mutual attraction between the moon and the earth. Taking the specific gravity of iron 8.0 and bearing in mind that the areas are as the squares and the masses as the cubes of the diameters, we arrive at the following results.

A mass of iron (globular) to weigh 20000 lbs sp. gr. 8 will be a little over 50.9 inches in diameter found thus:—

$$\sqrt[3]{\left(\frac{20000 \text{ lbs} \times 16 \frac{1}{2} \times 1728}{8000 \text{ sp gr} \times .5236}\right)} = \sqrt[3]{132009} = 50.9 \text{ in}$$

nearly. A similar mass of stone to be the same weight and spec. gr. 3.0 must be 70.6 in in diameter; found thus

$$\sqrt[3]{\left(\frac{132009}{3}\right)} = \sqrt[3]{352024} = 70.6$$

Now if a piece of stone 5.6 in in diameter weighing 10 lbs., be projected with a velocity of 9000 feet per second, a mass 70.6 in diam

eter, weighing 20000 lbs could only be projected with a velocity of 715 feet per second, because the weights would increase so much faster than the sectional area, thus as

$$\frac{20000}{10} : \frac{(70.6)^2}{(5.62)^2} :: 9000 \text{ Velocity.}$$

or as $2000 : \frac{4984.36}{31.36} :: 9000 : 715$

The mass of iron has a less sectional area than the stone because of its greater specific grav. viz. in the proportion of $(50.9)^2$ to $(70.6)^2$; it would therefore be projected with a velocity of 372 ft per second: or as $498436 : 259081 :: 715 : 372$

that is a velocity more than 20 times too small to allow of the larger known meteoric masses, especially iron ones, ^{to reach the earth} though not perhaps altogether subversive of the lunar theory generally.

After stating the objections which have been advanced to this theory of the lunar

origin of meteorites I conclude it with de
Sault's summary of his theory.

That the moon is the only large body in
space of which we have any knowledge,
possessing the requisite conditions demanded
by the physical and chemical properties of
meteorites, and that they have been thrown off
from that body by volcanic action (doubtless long
since extinct, reached such a distance as that
the moon exercised no longer a preponderating
attraction — the detached fragment, possessing
an orbital motion and an orbital velocity, which it
had in common with all parts of the moon, but now
more or less modified by the projectile force and new
condition of attraction in which it was placed with refer-
ence to the earth, acquired an independent orbit: more or less
elliptical. This orbit necessarily subject to great disturbing influ-
ences may sooner or later cross our atmosphere and be inter-
cepted by the body of the globe.

2.

THE PLANETARY THEORY.

This may be briefly stated to be the disruption of small planetary bodies or asteroids which would acquire velocities in several directions. This theory was advanced by Chladni and according to it a meteoric stone, ^{or iron} may be defined to be, true though minute planetary fragments but from want ^{of data} no demonstrative proof has as yet been made.

The idea that the smaller planetary bodies were formed by the impact and disruption of larger cosmical masses was propounded by Olbers to account for the existence of the asteroids; and D'Arrest and B von Littrow have in more recent times established by careful calculation, the possibility of the impact of these bodies actually taking place.

By the impact of two solid cosmical masses

moving with planetary velocity, fusion perhaps even vaporization, would occur over the area of contact; disintegration moreover would be a result; the fragments would be sundered with great violence and would acquire velocities in several directions, small fragments as well as large would be produced. Meteorites however are small masses. The largest known are the meteoric stone of Knyahinya, in the Vienna Collection, which weighs 294 Kilog and the meteoric iron of Cranbourne preserved in the British Museum and weighing 3700 Kilog. Most of them are of far less magnitude; and a stone of 5 Kilog is a large meteorite. It seems more probable that a disintegration even to the smallest particles has been brought about by a force acting from within outwards - in short by an explosion. Here however we have to meet the same

objection as in the theory by impact. When a cosmical body of considerable magnitude, whether solid or in part fluid is sundered by explosion, there will be produced, in addition to the numberless small fragments, large masses also, which become meteorites and set out in various orbits. It does not necessarily follow that the complete breaking asunder of the mass had occurred at a single explosion. But the disintegration of such a cosmical mass may be gradual. In place of a single explosion we may conceive a succession of them hurling portions of the surface into space. Such an occurrence may take place on any cosmical mass on which volcanic agencies may be active and the mass yet be so small that its gravitating power is insufficient to attract again to its surface all the fragments which have been hurled from it. Whether the action be simply

explosive, hurling upward the solid rock of the surface or at the same time also eruptive as on the earth, ejecting matter from the interior, in either case a difference will be observed between the crust and the nucleus of the rock. As meteorites reach us in the form of angular fragments, it follows that the star-mass whence they are derived must have possessed a solid crust; further we must conclude that the interior was either not solid, or had altogether a different constitution.

The average of the spec. grav. of about twenty stones is found to be 3.4, the highest being about 3.95 and the lowest 1.7; but as those possessing the smallest specific gravity are necessarily the most destructible and fragile, and after meteoric explosion less likely to arrive on the surface of the earth in an entire or tangible state, we may very fairly take their average

density nearer the mean of these two extremes say 3.0. We may now construct a table of densities (taking water as 1) which is not without interest as perhaps bearing on the subject in hand.

The spec grav of Mercury is about	15.7
..... Venus	5.9
..... Earth	5.7
..... Mars	5.3
..... Aerolites (3.9 to 1.7 say)	3.0
..... Asteroids	(?)
..... Jupiter	1.4

This then looks like additional confirmation of the theory of what are called meteorites, or aerolites, belonging to the series of planets, and having their orbits at a greater mean distance than that of the earth's from the sun. Bearing this in mind, as also the probability of the fact of our meeting with more of them on the

side of the summer solstice, or when the earth is at her aphelion. In elaboration of his idea Luy quotes very freely from Le Verrier in regard to the perihelia of the asteroids, known and unknown and he concludes that the sum total of the matter constituting the small planets situated between the mean distances 2.20 and 3.16 cannot exceed about one fourth of the mass of the earth. and summarizes his results.

First: That the deposition of meteoric matter on the surface of the earth has not been, all things considered, otherwise than uniform. Indly. That their origin is not within the limits of the earth's atmosphere. 3rdly That they are probably distinct from ordinary luminous meteors, as regards both their physical nature and orbits, and may also exhibit periodicity. 4thly. That their period of least common occurrence takes place when the earth is on the side of the winter solstice in perihelion and vice versa. 5thly That they may partake of the proper nature and conditions of planetary bodies.

PHENOMENA

ATTENDING THEIR FALL

The phenomena attending the fall of meteorites have been very accurately described by Haidinger, Greg, and Shepard and others, and von Haidinger has especially distinguished himself by the thoughts he has advanced from the study which he has made of them and I quote very freely from him. The phenomena take place without warning and occupying so short a period of time, it is only from persons accustomed to receive impressions promptly that we can obtain trustworthy observations. Dr Gustavus scheffczik, whilst on a hunting excursion, saw near Strakowitz in Bohemia, on the 29th of November, 1859, at 10^h 45' A.M., a luminous star-like point appearing

2 p.m.

suddenly on a clear sky, due north 15° zenith distance, increasing gradually to an intensely luminous globe, equal in size to one third of the full moon (about one third of her diameter). and passing along a parabolic path towards S 60° E.

When under an angle of altitude of 25° (azimuth $= 65^{\circ}$) it assumed an oval shape, the pointed end bent downwards and forwards, and lastly apparently dissolved into many large sparks, one of which evidently fell down in a vertical direction.

Dr Scheffczyk estimates the phenomenon to have lasted from four to five seconds. A noise as if myriads of birds were flying through the air attracted his attention. According to his watch $1\frac{1}{4}$ minute passed in silence after the disappearance of the luminous appearances; then followed, quickly after each other, four detonations (the last the most intense), resembling the discharges from heavy ordnance. The ground shook under the observers' feet, as was corroborated by three other gentlemen in company with Dr. S. who also heard the four-

detonations.

Scarcely any fall of aerolites has ever been so exactly and fully observed as that which fell at New Concord, Muskingum Co., Ohio, on May 1st 1860.

Professor Evans of Marietta College Ohio, calculated several elements of the orbit. The meteor first seen as a fiery globe at a horizontal distance of 20 to 30 (English) miles, appeared like the full moon.

An altitude of 40 miles, derived from other observations, would give to it a real diameter of $\frac{3}{8}$ ths of a mile. It moved from S. E. to N. W.

The final velocity was about four miles a second.

Nearly thirty stones of about 700 lbs. total weight, were found to have fallen; the largest of them weighing 103., lbs., is now in the Museum of Marietta College. All these stones taken together would fall far short of the apparent size of the meteor, as is the case with many observations of a similar nature, especially with that of Agram in Croatia.

May 26th 1751 where two masses of native iron, the one of 71 lbs., the other of 16 $\frac{1}{2}$ lbs., were the only

material residuum of a meteor whose apparent diameter was scarcely under 3000 feet. At first the New-Boucord stones were warm, so that particles of the moist-ground on which one of them had fallen, soon dried up, at least in the case of one weighing 71 lbs. Its greatest heat was not more than that which the stone would have had if exposed for some time to the natural heat of the sun's rays. The largest of the stones (103 lbs) was found about three weeks after the fall, beneath the root of an oak tree, It had gone through another root in an oblique direction, and had penetrated to the depth of nearly 3 feet into a hard argillaceous ground: no mention is made of its probable temperature at the time of falling. Those who witnessed the fall, only perceived that the stones were "black" they did not mention the appearance of any fireball.

At the moment of the fall they heard hissing sounds, and that before the chief detonation had attracted their attention. All the stones were covered with a black crust bearing evidence of fusion and

presented angular and fragmentary shapes; their interior resembled grey solid rocks. The American naturalists inferred from the collated accounts about the igneous globe, the acoustic phenomena, and the fall itself, that the first and chief detonation took place at an altitude of about 40 (English) miles above the southern portion of Noble County, at a distance of about 30 miles from New Concord; and that the fall of the stones themselves commenced about one mile S.E. of that place, extending over an area of 10 miles in length by 2 to 3 in breadth, the largest ones falling last. The sound was supposed to have been explosive in its nature; and the meteor after having ceased to be visible, must have continued its course to the northwest. These are some of the most of the most important facts relating to the phenomenon. Desirable as it is to pursue induction step by step, it is impossible to give a clear exposition without sketching previously the succession in time of each event as they are observed and perceived by our senses. The general form of

6 p.m.
 meteorites is that of fragments, the constitution of their external crust is the consequence of superficial fusion. They are fragments coming from cosmical regions, which have entered the earth's atmosphere, are first perceived by us as stars, increasing in size as they come nearer to us. Great care should be taken to observe and note the moment or time with as much exactitude as possible, as, combined with the time of the year and the hour of the day, it gives us the direction of the meteor. The direction and velocity of our globe in its circum-solar orbit (19 English miles per second, while a point on the equator by diurnal rotation moves 1464.7 verina feet in a second, or 900 nautical miles per hour) are well known.

Many observations tend to prove ^{that} meteorites travel 16 to 40 English miles in a second. Humboldt in his Cosmos has even, from the observations of J. Schmidt, Heis and Houzeau calculated a velocity of 95 miles a second. These orbits cross and oppose each other in every conceivable direction. Important

consequences may be deduced from these velocities as compared with that which takes place on the surface of our globe. A devastating hurricane takes place in our atmosphere whenever an air current is progressing at the rate of 92 (English) miles per hour. A point on the equator by diurnal rotation progresses at the rate of 1464.7 Vienna feet per second without disturbances of the atmospheric equilibrium on account of the general atmospheric pressure being nearly equal in places lying very nearly to each other. According to Sir John Herschel, the momentum of a "devastating hurricane" is equivalent to a pressure of 37.9 lbs. Vienna (32.81 lbs English) weight, on one square foot Vienna measure. The atmospheric pressure (= 32 feet of water) on one Vienna square foot is 1804.8 lbs., or, compared with that of the most powerful hurricane, as 55 to 1. The following synoptic table was calculated by Mr. Rouse, and is found on page 483 of Prof Schmidt's Manual,

Velocity of Wind.		PRESSURE PER SQUARE Foot in lbs Avoirdupois	CHARACTER of WIND
ENGLISH Miles pr hr.	ENG' sh ft. pr. SEC.		
60	88.02	17.715	Great Storm
80	177.36	31.490	Hurricane
100	146.70	49.200	Destructive Hurricane
913-916	1340.0	1 Atmosphere	

What is the state of the single particles of air composing our atmosphere in the elevated regions, where meteorites first entering it, are capable of producing luminous phenomena as intense as observed at New Concord, even at the enormous altitude of 40 English miles? In these elevated regions the temperature may probably not exceed that of the interplanetary space, i.e. 100° Reaumur. Movements of particles may be supposed indeed to take place in the higher regions of the atmosphere, as on these depend the changes of atmospheric pressure nearer to the earth's surface, the causes of the winds etc. In the van of the progressing meteorite a stratum of atmospheric particles is formed, having no time to escape before the progressing body, but by streaming back alongside of it.

Von Staudinger distinguishes two periods in the existence of any meteorite (1) from its primordial formation down to the completion of the of the body entering the terrestrial atmosphere; (2.) from its ~~completion~~ entering into the atmosphere down to its fall on the earth's surface. The last-period, being the subject of direct observation, must be especially treated here, although the former, still to be studied in many respects, cannot be left entirely out of discussion.

No qualities of matter or forces except those known at present can be admitted in explaining these phenomena. As early as March 14, 1861, von Staudinger distinguished the consecutive phases as follows:—

- I. A fragment pursuing its way meets the upper limit of the terrestrial atmosphere.
- II. Its cosmical velocity meets a resistance, and, in consequence, suffers diminution.
- III. Meantime pressure develops light and heat, the meteorite rotates, and an enamelled crust forms on its surface.

IV. The heated stratum of air agglomerates to an "igneous globe" behind the meteor.

V. The meteor having reached the term of its cosmic course becomes stationary.

VI. The development of light and heat ceases; the surrounding air rushing into the vacuum within the igneous globe causes a detonation.

VII. A compensation of temperature takes place between the cold internal nucleus and the external surface.

VIII. The meteorite, now subject to the laws of gravitation falls on the surface, its temperature standing in direct proportion to the thermo-conductive power of its substance.

Ad I. A fragment in its course meets the upper limit of the terrestrial atmosphere. - The existence of but one single fragment detached from a larger body is supposed, in order to simplifying the reasoning. Two or more fragments moving in the same direction under the impulse of the same force, either in immediate contact or with a greater or less distance between them, may

as well be supposed to enter at once the terrestrial atmosphere. Professor Daubrée expresses a different opinion, saying "Nothing entitles us to admit, as it has been asserted, that the different meteorites of the same fall traverse cosmical space separated from each other and, as it were, in swarms. Soⁱⁿ general the bolides leave us parts of their substance in three different ways 1st by combustion, vaporization, or gasification; 2nd by being dispersed into dust, the fall of which generally escapes observation, and which may be analogous to the dust gathered after certain meteoric falls; 3rd. by dispersion of the fragments detached at the moment of the explosion. The proceedings are such as if the greatest portion of the meteoric mass would pass from the atmosphere to continue its cosmical course, leaving behind only some particles whose velocity has been lessened in consequence of the explosion" Professor Daubrée admits still another supposition saying "There is no proof

that besides this sudden exhalation, these small planetary bodies are not endowed with an atmosphere of their own, which indeed they absorb soon after their entrance into our atmosphere. These gaseous substances, whatever may be their origin, may, by their combustion increase the splendor of the meteor; however as they would burn away in continuity, they leave unexplained the fact of the explosion preceding any fall of meteorites."

If Professor Daubree having entered into the most minute distinctions and called in to aid several very respectable suppositions, concludes with acknowledging the want of satisfactory explanations for the explosions, it must not be wondered at that M. St-Meunier speaks of their cause as "absolutely unknown." Haidinger says, In fact an explosion exists not, and therefore neither admits nor wants an explanation. The term itself is improper; and if instead of it - the term "detonation" is used, an inaccurate presupposition is eliminated and

explanation made easier. The first proposition may be expressed more precisely thus: A fragment (or a group of fragments) in its course meets the limits of the terrestrial atmosphere.

Ad. 2. The cosmical velocity of the fragments meets resistance and consequently is diminished.

~~This~~ Ad 3. Together with the diminution of velocity, the compression of the air develops light and heat, the meteorite takes a rotatory movement, and an enamelled crust forms on its surface.

Ad. 4. The heated stratum of air, due to the pressure of the meteorite deprived of its cosmical velocity, is pushed forward in proportion to the initial force of movement, and agglomerates behind it in an "igneous globe."

2. Luminous Phenomena. The diagrams on the following page may assist in the explanation of these phenomena. Pressure produces a center of expansion in front of the meteorite. The compressed air is forced out of it radially in every direction. The resistance remains equal against this luminous disc; only at some distance in the direction

Fig 1

FIG 2.

of the line of course it overcomes the luminous ~~disk~~; ~~only at some distance~~ and in incandescent stratum of air, pressing ^{it} at last behind the course of the meteorite. Movement is transmuted into light and heat. Professor G. V. Schiaparelli announces it in these terms "While the meteoric substance is dispersed through the atmosphere, this vis viva, being transformed into heat and light, is entirely destroyed." This explanation is rejected by M. Daubrée who says "The recent investigations as to the mechanical production of heat have induced some to suppose the heat of meteorites to be the consequence of their loss of vis viva. This supposition is in contradiction to the carbonaceous meteorites, which, instead of being hot as far as their center, as they ought to be according to ~~this~~ supposition, include substances liable to be altered or dispersed by a slight increase of temperature."

He has not, however, considered this transformation as proceeding not suddenly, but by degrees, in proportion to the atmospheric resistance, and only on the surface where the air is in contact with the meteoric nucleus. He supposes likewise

Fig a.

Athens Oct 18 1863 14^h 55^m Course of meteor E to W.

the meteorites to come cold out of cosmical space on account of their composition being easily destructible by heat, although he does not mention the extremely low temperature which must be supposed to exist in cosmical space. The learned Professor, when ascribing the thermal phenomena observed in meteorites to the development of electricity provoked by violent friction, is rather commenting on than contradicting von Hardinger's views.

It may be a question what idea is to be conceived of the dispersion of a swarm of meteors, different in size, without detonation, and at the ~~same~~ moment of quietly entering our atmosphere. Director Julius Schmidt has witnessed this phenomenon at Athens, October 18 1863 and it is represented in the diagram facing this page. fig (a)

The atmospheric resistance acts more powerfully on bodies of comparatively greater surface, while the larger and heavier ones move forward. The most minute particles remain behind in form of a tail. The telescope has dissolved into group what seemed to be a single meteor:

Fig 6.

it is as possible that bodies nearly approaching each other, and even wrapped up in the same meteoric envelope, may proceed in common. The sketch B on the page facing this may illustrate such a supposition. The largest fragment possesses of course, the greatest amount of momentum; although pressed backward it still leads in the van, the smaller ones likewise being pressed backwards. Those next to the larger ones cannot totally remain behind, as the larger leading fragments have determined the elements of the igneous globe by producing a center of elasticity (C) before it. All of them (E, F, G, H) must move forward within the anterior portion of the igneous globe, each single fragment in rotation on its own axis and around the axis of the line of course, and thus probably frequently come into mutual contact, by which their enamelled crust is damaged, as at Knyahynia, where nearly all the specimens collected were found more or less damaged. Of course the smaller fragments will follow the largest mass - although instances of several groups following each other have been frequently observed.

Ad. 5. The meteor, having reached the term of its cosmical course, becomes stationary

Ad. 6. The development of light and heat ceases: the surrounding air, rushed suddenly into the vacuum with the igneous globe, causes a detonation.

The igneous globe becomes stationary ~~globe becomes stationary~~ the moment the action of the vis viva of the movement has reached its term. At the same moment its equivalent has occurred to our senses. We have perceived the last seconds of the movement, together with the great display of light and heat into which it has been transmuted. Electricity has not been mentioned, as its presence has not been ascertained by direct observation, although its action may be supposed. Lightning itself is but "a transmutation of electricity into light:" and the late Professor Plücker expressly asserts with reference to the phenomena in Geissler's tubes, that "there is no electric light in the abstract sense of the term" and that "the particles of the gaseous substances become incandescent."

At the moment when the cosmical velocity as well as light and heat, is exhausted, the tension

of the vacuum within the igneous globe, entirely depending on this velocity, comes to an end, and the meteor obeys only the law of gravitation, causing it to fall on the earth's surface.

b. Acoustic phenomena.

The ~~sudden~~ disruption of the surrounding atmosphere into the vacuum of the igneous globe causes a violent sound. One or more detonations are heard, sometimes at intervals, the last one being the most intense. If previously masses, or groups of meteoric swarms, have separated from each other, repeated detonations may be expected.

As compensation of temperature takes place between the internal nucleus and external surface.

Without doubt the meteorites, before reaching the terrestrial atmosphere, take their course through a space of intensely cold atmosphere.

The incandescence of the enamelled crust during its formation is also not to be doubted. The efficient cause of this high temperature ceases as soon as the meteorite has become stationary. During its subsequent fall to the surface time is left for a compensation between the melting temperature

of its crust and the intense cold of its nucleus, and generally fallen meteorites are warm but not incandescent. Some meteoric irons (as at Baritas Paso in Corrientes, 1844) have been found incandescent in their interior - an apparent exception to be explained by the high thermal conducting power of iron. In the report of the meteoric fall of Dhurnsalla (India) some fragments are said to have been "intensely cold".

Ad 8. The meteorite, now subject to the law of gravitation falls on the surface, its temperature being in direct proportion to the thermo-conductivity power of its substance.

Dr G. von Lath has published a notice concerning the fall of Pullusk, especially with regard to the chemical and mineralogical constitution of the meteorites, of which he had occasion to examine above 1200 single specimens, and to compare them with those preserved in the museums of Bonn and Berlin. Fig 1. a. b. c. of this notice reproduces the anterior surface of a meteorite weighing 870 grms., on which the author (p. 4) comments thus: "The anterior portion of our

meteorite is characterized beyond any doubt by the presence and the direction of the seams of enamelled crust, by means of which the position of the stone during its telluric course before its fall may be ascertained.

According to Dr von Rath (p. 6) the meteorites of pullusk cannot be considered to be the results of the diffraction of one single cosmical body, but must rather be supposed to be a swarm of larger or smaller planetary individuals that had come within the sphere of terrestrial attraction and having most of them undergone diffraction, although the strongly flattened cosmical figure could still be traced on some of them. As von Haidinger remarks, seams of enamelled crust could not be formed on meteorites of quite irregular form, whose position necessarily changes at every moment of their course. During its cosmical course a swarm could remain in repose; but as soon as it enters the terrestrial atmosphere, the individuals composing it, in collision with each other, must undergo loss of sub-

lance.

During the continuation of the cosmical course through the atmosphere, the conditions for incrustation constantly remained extant, and fragments of secondary origin could be incrustated again.

From the moment of detonation the incrustated meteorites, having reached their point of dispersion fall down individually in more or less vertical direction; they may thus damage each other but no new incrustations take place.

Dr von Rath says further (p 27) "The meteorites, not quite dissimilar to telluric rocks, although for the most part so different from them, indicate conditions of formation as they were never found united within the known portion of the terrestrial crust"

"The explanation of the surfaces dotted with metallic or sulphuretted iron, presents great difficulties; at all events they are of cosmical origin while the lines and surfaces of fusion are of

telluric origin. This last assertion appears to our Haidinger to not to be quite ~~an~~ unobjectionable.

The enamelled crust, formed during the course, may under peculiar circumstances penetrate here and there into the substance of the meteorite; it must, however, be admitted that the internal clefts and fissures, partly filled up with a black enamel-like substance, having originated during the cosmical period of the mass, before its being broken into pieces which immediately began their course through cosmical space.

The apparent size of a luminous body has been shown by Prof Smith to exceed greatly its actual size, his experiments, made

1st - with the electric light between carbon points

2nd - with the oxy-hydrogen light falling on lime, and

3rd, - with the light from steel burning in oxygen, - the irradiation of a luminous point gives the following numbers for the

apparent-size at four different distances -

Distance	10 inches	600 ft -	1320 ft or $\frac{1}{4}$ mile	2640 ft or $\frac{1}{2}$ mile
1 Carbon	0.3 line	$\frac{1}{2}$ } DIAM ETER	3 } Diam	$3\frac{1}{2}$ } DIAM
2. Lime	0.4 "	$\frac{1}{3}$ } of	2 } of	2 } of
3. Steel.	0.2 "	$\frac{1}{4}$ } the	1 } Moon	1 } Moon

A disruptive explosion is only indubitable where, as in the stone fall of Pegu (December 27 1857) two fragments of the same stone, fitting each other exactly, have been found at a certain distance, such a disruption may cause a sound, as would a millstone under analogous circumstances, but certainly of less intensity than that caused by the sudden collapse of the vacuum within a large fire ball.

We have no right to speak of the explosion of large bodies within our atmosphere, while the so-called fragments of them show no marks of any explosion nor should we speak of superficial heating to fusion in our atmosphere, while masses of 50 lbs weight were found, ten minutes after their fall, not warmer than any stone exposed to the sun's rays, while

others fell on dry leaves without leaving on them any traces of combustion or heating. We can now adopt Prof. Smith's conclusions,

1st- The luminous phenomena attending the appearance of meteorites are not caused by incandescence, but rather by electricity or some other agent.

2nd. The sound comes not from the explosion of any solid body but rather from concussion caused by its rapid movement through the atmosphere, partly also from electric discharge.

3rd. Meteoric showers owe not their existence to fragments caused by the rupture of a single solid body, but to the division of smaller aerolites entering the atmosphere in groups.

4th. The black crust is not of atmospheric origin, but is already formed in cosmical space, before the meteorites enter our atmosphere.

Constitution of METEORITES

If we examine meteorites as regards their constitution it will be seen that some are formed of iron, evidently pure, while others consist of masses exclusively lapideous. Between these extreme types, specimens are found of a mixed nature, forming as it were a bond of union. Hence it is convenient to adopt a single name, applicable to all the substances which reach us from the skies to the iron as well as the stone and even to the pulverulent or gaseous substances which may have the same origin. Such a name is that of meteorite, while the name of aerolite should be rejected as designating exclusively stony substances.

I Holo siderous.

Meteoric iron forms masses destitute of stony matter and sometimes sufficiently pure to be susceptible of being immediately forged; it has even been em-

ployed in the fabrication of arms and utensils. To terrestrial mineral can, in this respect be compared to it; native iron, it is true, has been found on the surface of the globe, but always under exceptional circumstances, when it appeared to proceed from reductions accidentally effected, either by combustible gases generated in volcanoes or by the conflagration of coal-beds. We ascertain by the presence of the Widmannstätten figures that the body is at once crystalline and heterogeneous.

The falls of iron meteorites are incomparably more rare, at least at the present epoch, than the falls of those of stone.

II Syssiderous.

Certain iron meteorites, in place of being massive, include stony portions disseminated in a metallic paste which possesses continuity and forms a sort of metallic sponge. They thus constitute a first term of the transition of meteorites of iron to those of stone.

In the best known representative of the meteorites of this group, the stony matter, whose grains are imbedded in the iron, consists of a silicate with a base of magnesium and of protoxide of iron, constituting precisely the terrestrial species known by the name of peridot. This arrangement recalls in a striking manner certain products of iron accidentally formed in the workshops, in which the silicated scoria performs the part fulfilled by the peridot in the meteorites with which we are occupied. The meteorites of this group are represented by a celebrated mass of iron, discovered by Pallas, at Krasnojarsk in Siberia. The stony matter of these meteorites, to which we give the name of sissiderous (from the Greek σις = with to express the continuity of the iron, and σίδηρος (iron)) does not always consist exclusively of peridot: It sometimes comprises a silicate of a pyroxenic nature. In the two types of sissiderous meteorites the stone is in grains disseminated and discontinuous.

ous. But it may happen therein the stone is continuous as well, and at the same time as the iron; that is to say, that the mass results from the mutual entanglement of the two continuous systems, the one metallic, the other stony. Such among others is the meteorite of Kittersgrün.

III Sporadic.

The greater part of the meteorites are characterized by a stony paste, in which the iron, instead of being continuous, as is the two former groups, is disseminated in granules. The relation is then precisely the inverse of that which characterizes the type of Dallas and of Atacama. Each of these grains presents, moreover, the characters of composition and structure of the iron meteorites. Like them, they include nickel, and the phosphide and sulphide of iron. The grains of iron, other wise very variable in proportion, have also very different dimensions, from that of a hazel-nut or larger down to grains scarcely

visible, or even microscopic. Their form is irregular and frequently tubular. In this series, the extreme terms of which are so remote, but which are connected by a multitude of intermediate bodies, we may distinguish three subgroups.

Polysiderous 1st Sub-Group

In the first place, this sub-group, being the richest in iron, is represented by masses which their mixed composition might lead us to consider either as stone or iron. We may designate them by the name of polysiderous ($\pi\omicron\lambda\upsilon\varsigma$, = much); the metal and the silicates may exist therein in apparently equal volumes. Example Sierra de Chaco, Chili. yield Widmannstätten figures

Oligosiderous. 2nd Sub-Group.

The meteorites incomparably most frequent enter into the sub-group at which we now arrive. In ten falls, nine at least pertain to it; hence it may be designated as the common type. To the meteorites

which it comprises the name of oligosiderous (oligos, little) is given.

These meteorites are easily distinguished by their stony aspect from those of the preceding subgroup and easily from the preceding 1st two groups. The fracture, ordinarily of an ashy gray and rough to the touch, recalls strikingly that of certain finely-grained trachytes. The mass is entirely crystalline, as the microscopic examination of a lamina sufficiently thin immediately evinces. The paste appears at first view, almost homogeneous; but a more attentive examination enables us to recognize that it results from a mixture of different substances which pertain in general to five species readily distinguishable; three metallic, two stony and silicated.

First we find nickeliferous native iron in malleable grains, often small, proportion is variable, from 8 to 22 per 100 of the wet weight. Next iron sulphide (troilite), whose degree of sulphuration is inferior to

pyrrhotine. It approximates to the proto-sulphide; often in isolated grains, which their color, a bronze yellow, is easily seen, also exists in the globules of iron. Generally forms from 4 to 13 % of the mass and even 20% in the meteorite which fell 24th December 1858, at Murcia in Spain. Chromic iron, forms the third element, appears in small black grains, 0.2 to 2% of the total mass. Saugier in 1806 first pointed out the frequent occurrence of chromic iron. The prevailing constituent of meteorites of the common type is a mixture of silicates which are separated by acids. One is attacked by weak acids, the other is not and is rich in silicic acid. Often approximates to pyroxene. Have a globular texture - a gray substance deeper color than the mass, formed of different sized globules, formed chiefly of the bisilicate, not acted on by acids. These remain at the bottom in little grains. Gustav Rose gave to this group on this account the name of Chondrites from $\chi\omicron\rho\delta\rho\omicron\varsigma$ = a ball or granular concretion.

They present surfaces of friction analogous to the mirror-like slides seen in veins of mines. The rubbed surfaces are interrupted by the glass, which shows previous origin to the fall of the stones & to their division into fragments. External crust ~~dark and~~ dark and dull color. rusts in the air.

3rd- Sub Group Cryptosiderous.

Iron scanty, fine grains. The name cryptosiderous ($\chi\rho\upsilon\pi\tau\omicron\varsigma$ = hidden) expresses this character. It is a transition from metallic to non-metallic meteorites differs chiefly by the composition of its stony matter; chiefly aluminous. It is a mixture of two distinct minerals augite, pyroxene, and anorthite feldspar in confused crystallization, also ~~pyroxite~~ pyroxite in hexagonal crystals. The aluminous meteorites are called Eucrites or eukrites from $\epsilon\rho\chi\rho\iota\tau\omicron\varsigma$, distinct. Alumina and lime occur in greater proportion in this group than in others and magnesium less. In the aluminous, the external coating is lustrous instead of dull. has distinct striae and indurated globules.

examples are the stone of Juvenas, Hammer, & Gonzac. Second section of this group comprise the magnesian silicates. These are peridots, constituting nearly the whole mass.

IV. Asiderous.

No iron disseminated in a metallic state. nearly restricted to the carbonaceous meteorites

The presence of carbon, not-free or in graphitic state but in admixed combination with hydrogen and oxygen, & presence of combined water, and of soluble and even deliquescent saline constituents, also has sometimes a double carbonate of magnesian and iron called breunerite. Contains magnesian silicates, oxides of nickel, cobalt and chrome. also oxide of magnetic iron, pyrrhotite, ~~mineral~~ innumerable microscopic crystals, diameter = 1.30 of a millimeter & finally chrome iron.

Examples are Alais, Cape of Good Hope, Kaba & Argueil.

CLASSIFICATION OF METEORITES

GROUP		SUB-GROUP	EXAMPLES	DENSITY	
Siderites. Containing iron in a metallic state.	Pure; not containing stony or earthy matters. Containing at the same time iron, stony or earthy matter.	I. HoloSIDEROUS Iron, or alloys of iron and other metals.	Charcas	7.0 - 8.0	
		II. Syssiderous	Rittersquien	7.1 to 7.8	
		III. Sporasiderous	Polysiderous Quantity of iron considerable	Sierra de Chaco.	6.5 - 7
			Oligosiderous Quantity of iron small	Aumale	3.1 - 3.8
Asiderites. Not containing metallic iron.	The iron is disseminated in grains.	Cryptosiderous The iron imperceptible to sight.	Chassigny puumas	1.9 - 3.8	
		IV. Asiderous.	Nonmetallic iron	Orqueil	1.9 - 3.6

PAUL PARTSCH'S CLASSIFICATION

I NORMAL

1. Containing no metallic iron

2. Iron disseminated

Juvinas
 stannin
 Constanti
 nople
 Pongac

II. Abnormal.

Alais
 Capeland
 Chassigny
 Sinc brot

III Meteoric Iron

I Netted. containing Olivine

II Compact

GUSTAVE ROSE'S

CLASSIFICATION

I. IRON METEORITES

1. Consisting of nickeliferous iron, chemically united with the iron

METEORIC IRON

2. Metallic iron interspersed with Olivine

PALLASITE

3. A granular mixture of meteoric iron and pyroxene with Olivine and Augite

MESO-SIDERITE

II. STONY METEORITES.

CHONDRITE

1. Chondrites.

Contains
 Magnesia
 silicates,
 Olivine +
 Chromic iron

HOWARDITE

2. Howardite a fine grained mixture of Olivine with a white silicate + a small quantity of Chromic iron + Fe/Mn

Stony Meteorites Continued

Chassignite

3. Chassignite. a fine grained Olivine rich in iron with a very small amount of small grains of Chrome iron

Chladnite

4. Chladnite. A mixture of $Mg_2 Si_3 O_2$ with an undetermined aluminous silicate containing small quantities of nickelliferous iron, Pyroxene and one other undetermined substance.

Shalkite

5. A granular Shalkite a granular mixture of Olivine with Shepardite & Chrome iron. Olivine predominating

CARBONACEOUS

6. Carbonaceous. still not accurately examined.

EUKRITE

7. Eukrite Consists of a granular mixture of augite and Anorthite with a small quantity of Pyroxene.

MASKELYNE'S CLASSIFICATION

I. AEROLITES.

Consisting of various silicates interspersed with isolated particles of nickelliferous native iron, meteoric pyrites. (Troilite) etc.

II. SIDEROLITES

Consisting of nickelliferous native iron, in a more or less continuous or sponge-like state (with schreibersite or cavities charged with silicates etc)

III. AEROSIDERITES.

Native iron, nickelliferous, and phosphides of nickel and iron, carbon, Troilite etc.

CLASSIFICATION

II, TYPE. With white mass.

1 Group. white with
light grains
enclose of
bluish white

2 Group. { white with
dark grains
rough.

White with
dark and
light-grains
mixed.

III TYPE { Gray.
Gray and white speckled.
White grains enclosed
Dark gray

IV Type greenish.

V. Carbonaceous

VI Reddish brown.

VII TYPE. The transition member
between stone and metal

1 Group, with
reddish olivine

2 Group with
stone matter
enclosed.

VIII TYPE. The crystalline metals with
edges of nickelliferous iron

IX TYPE Metals without widman
stätten figures

1 Group. Transition member

2. Group. With needles and points

3. Group with lumps of white iron

4. Group with incisions.

5 Group. Internally, apparently
amorphous.

SHEPARD'S LATEST CLASSIFICATION

<p>CLASS. I LITHOLITES Stoney (Λίθος = a stone)</p>	<p>Sub-class I</p> <p>EUCRITIC Crystalline earthy indi- viduals dis- tinct. (Ευχρίτος dis- tinct)</p>	<p>Order 1st. Feldspathic Contains one or more species of feldspar Order 2nd. Augitic Contains augite</p>
	<p>Sub-class II. Dyscrithic Earthy indi- viduals in- distinct Ανοχρίτος = in- distinct</p>	<p>Order 1st. Psammitic Ψαμμος = sand. Has the structure of sandstone Order 2nd. Howardic, compact masses Order 3rd. Oolitic with oolitic grains Order 4th. Porphyritic sub-porphyrific Order 5th. Basaltic Trappear.</p>
	<p>Sub-class III. ANTHRACIC Black. (Ανθραξ = coal)</p>	<p>Order 1st. Alatine (Αταλός = soft) Friable. Order 2nd. Anlatene from α πωατεν + ατάλος, firm Firm</p>
<p>CLASS II LITHOSIDERITES Stone and iron mixed. (Λίθος + Σιδηρος iron)</p>	<p>Sub-class I PLEIOLITHIC More than half stone (Πλειών = more)</p>	<p>Order 1st. Stigmatic (Στίγμα a spot) Iron in round spots</p>
	<p>Sub-class II MEIOLITHIC Less than half stone (Μειών, less)</p>	<p>Order 1st. Mignamitic (Μίγνυμι to mix) Stone and iron much mixed.</p>
<p>CLASS III (See over)</p>	<p>Sub-class I. PSATHARIC Brittle (Ψαθαρός = brittle)</p>	<p>Order 1st. Chalyptic (Χάλυψ, steel) Steel like</p>

SIDERITES
chiefly iron

Sub-class II.
Apsatharic
Tough
(Αψαθαρός =)
tough

Order 1st- Agrammic
Without lines when etched

Order 2nd. Sporagrammic
With scattered lines

Order 3rd Microgrammic
Lines very small.

Order 4th Eugrammic
Lines distinct

Order 5th Megagrammic
Lines coarse

Order 6th Taeniastic
(Ταινία, a ribbon,
Banded.

Order 7th Nephelic
(Νεφέλη, a cloud)
Clouded.

1st. GROUP
Holosiderous.

Masses of meteoric iron from Augusta Co. Va
These three masses will be spoken of respectively as
Nos. 1, 2, & 3.

No 1. weighs about 56 lbs. its exact weight before cutting
was 25,429 grams. No 2, 16,441 grams No 3, 1,644 grams
All three present the same general appearance. They
are of an irregular pear shape, one end of each mass
being larger and more rounded than the other - the
smaller end of each is somewhat flattened, but by
concave surfaces, in one direction.

The dimensions of the masses before cutting were as
follows,

	No 1.	No 2	No 3
Maximum length	28. centimeters	27 c.m.	11 c.m
" width at large end	21 "	10 "	9 "
" " small end	17 "	19 "	5 "

	No 1	No 2	No 3
Maximum thickness at large end	13. c.m.	13 c.m	8 c.m
" " " small "	11 "	5 "	3 "

The following drawings are prepared from ~~the~~ ~~same~~ ~~specimens~~ ~~specimens~~ ~~specimens~~. The exact-weights before cutting were

No 1	No 2	No 3
25429 grams	16441 grms	1644 grs.

At some points which have been rubbed, the iron exhibits its metallic lustre, and traces of its crystalline character may be observed, but nearly the whole surface is covered with a dark brown crust, consisting essentially of hydrated ferric oxide, which varies from about an eighth to a third of an inch in thickness. This crust is hard, and pretty firmly adherent. The union of hardness and toughness in the iron makes it quite difficult to cut, and in attempting to obtain with a plane an ordinary piece, the tools were blunted and broken.

The specific gravities of nos 1 & 2 were taken with solid pieces of about 140 grams and 95 grams, respectively, cut from the interior of the masses, and for no 3, with about 10 grams of clean shavings in a specific gravity bottle. The results were,

Densities at -15°C . No 1 No 2 No 3
 7.853 7.855 7.839

The interior structure of the iron is compact and highly crystalline, there are minute fissures running through several portions of the metal.

~~Examining the exterior made upon the sides~~
~~examined on the exterior, etc.~~ The iron is not passive, though very easily rendered so by Nitric Acid. The following analyses, by showing an appreciable quantity of manganese have led me to accord these masses a front-rank among the species, and as the silica present is supposed to be in combination with the iron rather than with the manganese, it cannot be said to contain stony or earthy matter.

	No 1	No 2	No 3
Iron	88.706	88.365	89.007
Nickel	10.163	10.242	9.964
Cobalt	.396	.428	.387
Copper	.003	.004	.003
Zinc	.002	.002	.003
Manganese	trace	—	trace
Phosphorous	.341	.362	.376
Sulphur	.019	.008	.026
Chlorine	.003	.002	.004
Carbon	.172	.185	.122
Silica	.067	.061	.056
	99.872	99.659	99.947

J. W. Mallet - to whom I am indebted for the complete analysis just given, does not believe the Chlorine to be of meteoric origin

It seems probable that these masses represent portions of a single fall, agreeing as they do in external character and internal structure and in

Babb's Mills
Tenn.

BURLINGTON,
N.Y.

density and chemical composition, and having been found at but short distances from each other. The precise localities from which they came are as follows,

No 1, from a spot on the land of Mr Robert Van Sear, about 5 miles (a little East of) North from Staunton, in $38^{\circ} 14'$ N. Lat. and $79^{\circ} 01'$ W. Long

No 2. From the land of Mr M. Fackler, about one mile to the Southeast of the locality of No 1

No 3, about half a mile and still further south-east, or rather a little North of a N.W. and S.E. line passing through the last-named locality.

The Native iron at Scriba, N.Y.

No part of the specimen exhibited any accumulation of rust, its color, where a fresh surface had not been exposed, was iron black. The fresh surface is light-steel gray. The texture is exceedingly fine, and when polished affords a high lustre.

Its specific gravity is 7.5 Shepard's analysis
afforded Iron 99.68 Silicon 0.20, Calcuim .09

traces of alumina = 99.97

- From Potosi.

H. M. Juber, a lieutenant in the French Navy
among other minerals presented to him, brought
from Peru a piece of meteoric iron found near
Potosi in Bolivia. It was stated to him to be met-
eoric iron of great purity; it is cavernous, being
filled with vacuities, most of which are irregu-
lar, but some have the form of a rhombic dode-
cahedron; some of them also are filled with
a greenish vitreous substance similar to the
Olivine of Pallas. The tenacity of this iron is
extremely great, but it is readily hammered
and filed. It does not oxidize even when ex-
posed to a moist atmosphere. Its Density is
7.736 The mean of three analyses performed
by M. Morren gives as its composition, over

Iron 90.241 Nickel 9.759 = 100.00 This iron is remarkable from containing such a large percentage of Nickel; no trace either of copper, cobalt or manganese was discoverable. Deposited in the Museum of Angers.

- Bahia Brazil, $10^{\circ} 30' S$ lat., $33^{\circ} 15' W$ long. from San Salvador. Discovered by Bernardus da Neta Botelho in 1784. Described by A. F. Moray in 1816. This mass was seven feet long, four wide and two thick, and weighed 17,300 lbs. Exhibits imperfect Widmannstättian figures and contains small quantities of magnetic pyrites. Analysis by Wollaston

Iron 94. Nickel 4 = 98.

- Black Mountain, North Carolina - Gros-Tucuman, Argentine Republic. Described by Don Miguel Rubin de Celis in 1783. Weight 30000 pounds. A mass weighing 1400 lbs in the British Museum is believed to be from

the same locality. This mass was covered with a crust of oxides four to six inches thick, on the under side. It has cavities of various sizes which are more or less filled with magnetic pyrites. Structure highly crystalline, and when etched presents surfaces resembling crystalline masses of antimony and bismuth. It is very malleable. Density = 7.54 - 7.6 Rumler. Analysis by Howard.

Iron 90 Nickel 10 = 100.

- Senegal, the Upper Senegal, Africa. Made known by Compagnon in 1717. Vast quantities are said to be scattered over the countries in the Bumbuk and Siratik countries, several pieces of which have been brought by the negroes to Fort St Louis at the mouth of the Senegal. Compact with a very slight admixture of magnetic pyrites. By etching, short-raised lines appear, which are parallel

or intersect each other at various angles presenting like the Tucuman iron a striped or plumous appearance. When deeply etched the surface becomes granular Density = 7.72 Rumler Analysis by Howard

Iron 95. Nickel 5 = 100.

— Cape of Good Hope between Sunday and Boschman's rivers, Cape Colony, Africa. Discovered in 1793. Described by Barrow in 1801, and by van Marum in 1804. The original mass weighed over 300 lbs, of which 171 lbs are now in the cabinet of Natural History at Haarlem in Holland. Capt. Alexander discovered in 1837 great numbers of metallic masses, supposed to be meteoric, over a large extent of country along the Great Fish River in Cape Colony, which are supposed to belong to the same fall with the above. Compact, with a small quantity of finely divided magnetic pyrites. When etched

exhibits no Widdmannstätten figures. Density
 = 6.63 - 7.94 Rumler. Analysis by Wehrle
 Iron 85.608 Nickel 12.275 - Cobalt 0.887 - 98.770
 - Agram (Hraschina) Croatia. This most-
 interesting mass which fell May 26, 1751, and
 for nearly 100 years was the only one of the
 metallic class positively known to have fallen from
 the heavens, was first seen as a brilliant fire-ball
 passing from west to east through a cloudless
 sky at 6 P.M. attended with a noise like that
 produced by heavy wagons rapidly passing over
 a paved road. When almost directly over the village
 of Hraschina, it burst with a tremendous detona-
 tion into two pieces and at the same moment
 became enveloped in a cloud of smoke, which was
 at first black, and then presented a variety
 of colors. The fall was followed by a terrible
 crash, and a tumbling as from an earthquake.
 The larger fragment which weighed 71 lbs (Aus-

trian) made an opening in the earth 18 feet-deep and two feet-wide, while the smaller of 16 lbs weight-buried itself in a meadow 2000 paces distant. The large mass was presented to the Emperor Francis I, and the Empress, Maria Theresa, by the Bishop of Agram and is preserved in the Imperial Museum at Vienna: the smaller mass is missing. The mass has a triangular, tabular form with one side convex and the other slightly concave. It has a complete crust, in which is enclosed no gravel or earthy matter, as must have been the case had it been in a liquid condition. It undoubtedly came to the earth in a glowing state, and revolving rapidly like a circular saw so as to strike the ground edgewise, and thus penetrate to such an astonishing depth. The surface presents the usual concavities. The crust is brownish-black and without lustre, with a thickness of about $\frac{3}{4}$ ths of a line, though varying on

different-parts. It is somewhat fibrous in structure and readily separated from the metal beneath, which then appears smooth and polished. On the convex side of the mass, the crust contains numerous fissures, usually about one half inch long, though rarely from one to two inches, and from two twelfths to three twelfths of a line deep. The mass contains occasional intermixtures of magnetic pyrites, and displayed on fractured surfaces a crystalline structure. When etched, it exhibits most-perfectly those characteristic figures which were first-discovered in this iron, by Widmannsblätt in Vienna in 1808. Density 7.72 - 7.82 Rumler. Analyses

	Klaproth	Wehrle
Iron	96.6	89.784
Nickel	3.5	8.886
Cobalt-	—	0.667
	<u>100.1</u>	<u>99.337</u>

14-13

— Szlanica, near Arva, Hungary. Found in 1843. Described by Haidinger in 1844. Discovered in digging for iron ore and was invested by a thick crust of hydrated oxide of iron, in which were observed a few crystals of vivianite. The mass consists of a multitude of small, ellipsoidal globules of metal apparently cemented together by thin veins of pyrites and crystalline plates of schreibersite. The pyrites occurs also, in small, compact masses. When etched on polished surfaces, it displays no Widmannstättian figures, but becomes dull and of a light gray color. The edges of the plates of schreibersite appear upon such surfaces as brilliant lines and bands, arranged without order and of various dimensions, sometimes being half an inch in length and one twelfth in thickness. At a meeting of the Friends of Science at Vienna in 1847. A. Patera presented the results of his

analysis of the meteoric iron of Arva. A Lower the description of the place where it had been found and of the iron itself had already been published in the Vienna Zeitung of the 17th of April 1844 and of March 1845. The fragments of the pure iron employed in the analysis had a specific gravity of 7.814. The iron contained according to the qualitative examination; iron nickel, a trace of Cobalt and an extremely small quantity of Copper. The oxidized surface contained in addition Sulphur, carbon, Silicon Phosphorus, Potassium (?) probably as essential ingredients. The results of these analyses were

Iron	89.42	93.13	94.12
Nickel } Cobalt }	8.61	5.94	5.43
Residue, of Schreibersite Silicon. Carbon Copper & Sulphur	1.41	—	—
	99.44	99.07	99.55

14-15

93

A. Lowe's results are

Iron	90.471	91.361
Nickel	7.321	7.323
Cobalt-		
Schreibersite		
Silicon	1.404	0.938
Carbon		
Sulphur	99.196	99.622

The Schreibersite, examined by Patern, consisted of folia of flexible and strongly magnetic grains hardness 6.6. Density 7.01-7.22. Analysis the mean of three determinations by Patern is Iron 87.20 Nickel 4.24 Phosphorus 7.26 Carbon (?) = 98.70. It is stated that some carbon was obtained but the quantity was too small to be definitely estimated.

— Schwetz, on the river Weichsel, Prussia.

Found in 1850. Described by G. Rose in 1851

Weight 43 lbs 4 oz. Discovered in excavating a

and hill on the line of the East Railroad, at the depth of 4 feet. It had the form of a right-rectangular prism, with rounded edges. It was inclosed in a thin crust of hydrated oxides, and intersected by two or three seams, so that by means of chisels and hammers, it was easily divided into three pieces. The most of it is preserved in the Royal Museum at Berlin. The metal incloses a few small masses of magnetic iron pyrites. It exhibits when etched the Widmannstättenian figures very perfectly, the whole surface being ornamented by two sets of very long straight bands one eighth of an inch wide, which cut each other at angles of 60 and 120°, while a third set much wider and shorter, intersect these somewhat irregularly. Density = 7.77 Clark.
Analysis by Rammelsburg

	Metallic portion	Insoluble part
Iron	93.18	22.59
Nickel	5.77	34.77
Cobalt	1.05	4.74
Insoluble	0.96	3.90
	<u>99.98</u>	34.13
		<u>100.13</u>

— Petropawlowsk, Altai Siberia. Described by Sokolowskji in 1841. Several small specimens of meteoric metal were found at the depth of $31\frac{1}{2}$ feet below the surface. The largest mass was of irregular form, and coated with a crust of hydrated oxyds.

Its weight - was $17\frac{1}{2}$ lbs. Density 7.76

Analysis by Sokolowskji

Iron 97.29, Nickel 2.07 = 99.36

Salt-River Kentucky

Locality unknown. A specimen weighing two ounces, and found among the minerals of Prof. Stromeyer, by Prof. Wöhler of Göttingen. Density 7.547. Analysis by Marross.

Iron 92.33 Nickel and cobalt-7.38 Tin 0.03

Phosphide of Iron and Nickel 0.42 = 100.16

Oldham County Kentucky. Time of fall unknown. Discovered in October 1860 by Wm Daring near Lagrange. Described by J. Lawrence Smith in 1861. Weight-112 lbs. Extreme dimensions were $20 \times 10 \times \frac{3}{4}$ inches and $6\frac{1}{2}$ inches thick. Shape elongated and flattened. Density 7.89

Analysis by Smith

Iron

91.21

Nickel

7.81

Cobalt-

.25

Copper minute quantity not estimated

Phosphorus

05

99.32

Robertson Co. Tennessee. Time of Fall unknown.
 Discovered by Mr D Crockett near Coopers town
 Weight - 37 lbs. Density Smith 7.85. Extreme di-
 mensions are $10 \times 9\frac{1}{2} \times 5\frac{1}{2}$ inches. Form, wedge
 shaped. Described by J. Lawrence Smith in 1861
 Analysis by Smith Iron 89.59, Nickel 9.12
 Cobalt - .35 Phosphorus .04 Copper not estimated
 = 99.10

New Mexico. Time of fall
 Described by F. A. Genth 1854. Density, Genth, 8.130
 (at -18° Cels) It is very crystalline, quite ductile Analyzed
 by Genth

	I	II
Iron	96.17	95.92
Nickel	3.07	3.67
Cobalt -	0.42	
Insoluble	<u> </u>	<u>0.57</u>
	99.66	100.00

The insoluble part consists of. Iron 55.07 Nickel 28.78
 Titanium (?) 16.15 = 100

LENARTO

98

Saroszer No. Hungary, on the border of Galicia

It was discovered in 1814 towards the close of October in the vicinity of Barfield by a shepherd, near a spring under the dirt and decayed branches.

It was first described by Sernowitz in 1815-

It weighed 108.640 kg and its chief mass is now in the National museum at Pesth 74.760 kg

Pieces of it are found in many other collections especially in Vienna 3 kg. 2928 London 1 kg 829

Paris School of Mines 1 kg 250 Berlin 446.154 grms

Harlem, Teyler's Mus. 130 grm Paris Mus. nat Hist 116 grm. Gottingen 102 grm. and smaller pieces

in Bern, Bologna, Breslau, Calcutta, Copenhagen,

Gotha, Petersburg, Prier, Upsala, Utrecht. as also

Prince Lobkowitz in Berlin 2 kg 990 Greg 259 gr.

De Luyne in Dampierre 148 gr. & smaller pieces of

unknown weight, to von Reichenbach, Shepard,

Quertach, Neill, Fischer in Hamburg, Erz Stephan

in Schänburg Ferber in Gera. Neumann in

in Prague, von Hrnkslein in Gratz, Kessler
in Frankfurt, a. M. Baron von Brudern possesses
according to von Schreiter a piece of ~~almost~~ 21 kg.
Density 7.798 Wohle, 7.720 - 7.800 von Schreiter
+ 7.784 Krumler

It possesses an irregular tabular form, and
was crystallized upon the surface in rhomboidal
plates. It was covered with a crust of dark brown
metallic oxides and contains cavities. The metallic
portion incloses magnetic pyrites in the form of
small grains and lumps, as well as in larger
reniform + cylindrical masses. When etched or
laminated, it exhibits distinct Widmanstätten
figures which are mostly isosceles triangles.
The bands cross at angles of about 77° ; $77^\circ + 26^\circ$ varying in length
from six to fifteen lines, and in breadth from seven to
fifteen hundredths of a line. The intercellular spaces are often
beautifully halsted. Analyses were furnished by
von Holzer I. Wohle II. + Stark III.

	<u>I</u>	<u>II</u>	<u>III</u>
Fe	85.04	89.119	90.153
Ni	8.12	8.283	6.553
Co	3.59	0.653	0.502
Mn	0.61		0.145
Cu		0.002	0.080
Si	0.01		
Ca	0.63		
Mg	0.23		
Al	0.77		
Su			0.082
S			0.482
Insol Phos.			1.226
	<u>99.00</u>	<u>99.998</u>	<u>99.223</u>

Clark found a trace of phosphorus. Boussingault
 proves the existence of 0.010% Nitrogen. Also he
 found specs of graphite.

Translated partly from the German

Dysiderous. 2nd Group.

The Texas iron. Presented to Yale College by Mrs Laura Gibbs, its weight 1635 pounds.

A section made, revealed the crystalline structure of the mass, these lines were made to appear more clearly by washing the polished surface with dilute HNO_3 . Weight 1700 lbs. Found 1808

The iron was dissolved in HCl and a very small amount of insoluble matter remained, the composition of this residue according to B. Silliman Jr. consists of

Iron 31.2, Nickel 42.8, Phosphorus 4, Carbon 5.

Antimony ? and Copper 9.3 = 92.3

The mean of several analyses of the entire mass is, Iron 90.91, Nickel 8.462, Insoluble, phosphorus etc 0.600 = 99.873, density undetermined.

- Charlotte, Dicks on Co Tenn. Fell July 31 1835. Originally weight about 9 lbs, present weight 7 pounds 13 ounces. Its fracture shows some regularity of crystallization Density -

Fig 1

Fig 2

Fig 3

The accompanying illustrations show viz.

Fig 1. - $\frac{1}{2}$ the natural size and general outline

Fig 2 - Superior surface, Fig 3. this surface powerfully magnified.

The Lockport-iron. Fell at Lockport on the 1818. Weight 36 lbs Density

Its analysis by Silliman Jr is as follows.
Insoluble residue

Iron 44.1; Nickel 24.5; Phosphorous 11.4 and Silicon(?) 10.0 = 90.00 The deficiency in this result is said ^{to be} due probably to the fact that the iron occurs in the compound, as magnetic oxyd which is here estimated as metallic iron.

The following is presented as the constitution of the entire iron,

Iron, 92.583; Nickel 5.708 Copper and Arsenic, traces; Insol. matter 1.4 = 99.991.

Bohumilitz. Age unknown. Found in the circle of
 Prachin in Bohemia on the 19th of September 1829
 by a ploughman. Preserved in the National Museum
 at Prague. Described in 1830. Weight-103 lbs. Was covered
 with a thick crust of limonite. It is composed of a
 metallic mass, a large quantity of magnetic pyrites
 and an unknown substance which is black, not
 very hard and not-graphite. The black mineral occurs
 in the interior as well as at the surface of the mass,
 sometimes in portions nearly an inch in length and
 is intimately mixed with finely divided metal and
 pyrites. These black masses are enclosed in a coating of
 magnetic pyrites. According to Professor Gipsse, this mass
 is marked on the surface with irregular rounded impres-
 sions, paler than newly filed bar iron. According to
 Steimman its density is 7.146. Composition is
 Iron 94.06 Nickel 4.01. Plumbago and insoluble
 matter 1.12 Sulphur 0.81 = 100.00

This mass was also examined by Berzelius, Analysis

(1) Iron 92.473 Nickel 5.667 Cobalt-0.235 Insoluble 1.725 = 100.00

(2) Iron 94.775 Nickel 3.812 Cobalt-0.203, Insoluble 2.200 = 100.00

Berzelius dissolved 60 grammes of filings from the mass in Nitric acid, and found of insoluble carbonaceous matter 0.672 grs and of crystalline magnetic scales 0.777 grms. The first contained carbon alurnina, silica, iron, nickel, phosphate and chromate of iron. The second consisted of,

Iron	65.987
Nickel	15.008
Silicon	2.037
Carbon	1.422
Phosphorus	14.023
	<hr/> 98.467

Braunau, Bohemia. Fell in two fragments on the 14th of July 1847 One fragment weighed $42\frac{1}{2}$ pounds and the other 30 lbs

Density

Analysis by N. W. Fischer

afforded the following,

Iron 91.852, Nickel 5.517 Cobalt-0.529 Copper

Manganese, Arsenic, Calcium, Magnesium,
Silicon Carbon, Chlorine, Sulphur, 2.072
= 100.00.

Since the completion of this analysis, the presence of nodules of iron pyrites, in which Professor Fischer has detected carbon, phosphorus and chromium, has been proved.

Professors Duflos and Fischer have ascertained the presence of three heterogeneous substances. One of these is by far the most predominant, forming the general mass, and is a compound of iron, nickel, and cobalt, with traces of other substances as stated previously.

The second body occurring imbedded here and there in the general mass and which is readily distinguishable therefrom by its color, fracture, brittleness and lustre, may be extracted without difficulty by mechanical means.

The third, in fine, can be separated from the metallic iron in the form of small plates or spangles, by allowing the action of Hydrochloric acid.

In the imbedded substance the presence of Iron, sulphur, Nickel, Chromium, and Carbon.

In the metallic scales were found Iron, phosphorus, nickel carbon and silica.

This iron is regarded as almost identical with the Bohumilitz iron just mentioned, in this Berzelius examined the scales and found them to contain

Iron 65.977 Phosphorus 14.023 Nickel 15.008

Carbon 1.422 Silica 2.007 = 98.437

-Ruffs Mountain Newberry S. C.

The density of the internal portions of the mass is from 7.01 to 7.10; of exterior (where it is mingled with magnetic oxyd of iron) 5.97-6.80

Composition,

Iron 96.00 Nickel 3.12 Chromium, sulphur
cobalt, magnesium and chlorine traces = 99.12
The internal structure of this beautiful iron
resembles closely those of Texas and Carthage
Penn, although it differed from those by
presenting here and there small gashes or
veins filled with a very peculiar pyrites which
may prove a new meteoric species.

Prof Shepard found potassium in the rust-
which covers the layer of one margin, the
accompanying drawing represents the stone
which was examined by him.

Jacatecas, Described in the Gazeta of Mexico
April 3rd 1792, also described by Sommeschmidt,
Humboldt, Bergmann and others. Weight about
2000 lbs. Has a light steel gray color within, a
hackley fracture, and the crystalline figures are
small and irregular. Density, Bergmann 7.4891
Density Rumler 7.55. It is mixed with an unusu-

ally large quantity of pyrites, partly in globular masses which are connected together by the same mineral, so as to form on polished surfaces a sort of imperfect network. Widmannstättian figures can not be detected. Analysis by Bergmann,

Iron 85.094 Nickel 9.895 Cobalt 0.668 Copper 0.030 Magnesium 0.187 Carbon 0.164 Graphite 0.334 Schreibersite 1.646 Chrome iron 1.482.

Sulphur 0.845, Manganese ? = 99.348

Nickeliferous iron 93.77 Magnetic pyrites 2.27

Chrome iron 1.48 Schreibersite 1.65 Carbon 0.49

= 99.66

- Wayne Co. Ohio. Fine of fall. Described in 1864 26-50 lbs. Exhibits the usual figures Density, Smith 7.901. Analysis by J. S. Smith, Iron 93.61 Nickel 6.01 Cobalt .73 Copper very minute not estimated, Phosphorus .13 = 100.48

There was a very small quantity of manganese estimated with the nickel.

Nebraska. Time of Fall unknown. Described in 1860. originally weighed 35 pounds, found on the right shore of the Missouri River in Nebraska 25 miles west of Fort Pierre $44^{\circ} 19'$ lat and $100^{\circ} 26' W$ of Greenw., whence it was brought in 1857 and presented to the academy of St. Louis in 1858. It weighed $30\frac{1}{2}$ lbs. ~~Anal.~~ Density Shepard 7.735. Analysis by A. A. Prout, Iron 94.288 Nickel 7.185 Magnesium 0.650 Calcium 0.350 Sulphur trace = 102.473 but not the least trace of cobalt, chrome, manganese or any other constituent. The widmannstathian figures show the closest resemblance to those of the Red River iron preserved in the Yale College Cabinet.

Mr Shepard's investigations lead him to form a very different conclusion in regard to the earthy constituents he says "The Nebraska iron is quite free from earthy matter" whereas Mr Prout finds the total amount of earthy matter to amount to 1 percent of the mass.

TULA

- Tula. Russia. Found in 1846, 7 versts or 4.6 miles from the station Mariinskoje on the Moskaw - Tula Road ($54^{\circ}35'$ N lat., and long., $37^{\circ}34'$ E of Greenwich.) It weighed over 15 puds or 542 avoirdupois pounds. In the British Museum collection there are 3 specimens weighing 2 lbs 4 oz and 356 grs.

It was sold for four roubles or three dollars to the Myschega iron works in the neighborhood, where the greater portion of it was worked up into axles, wagon springs, grapnels and other implements until in 1857 Dr Auerbach learned of its existence and saved the remainder from destruction. It was first noticed by him in the Bulletin of the Imperial Society of Moscow in 1858 and in a preliminary analysis of it he found the mass to contain: Iron = 93.5 Nickel = 2.5, traces of Tin and 0.9% of schwei-

tersite. It yields sulphuric acid, when dissolved in chlorhydric acid, probably owing to the presence of pyrrhotine. Articles manufactured from this iron show after etching a beautifully damasked surface.

At the meeting of the Imperial academy of Vienna of Nov 18th 1860 W. Haidwiner has communicated some very interesting observations made on a specimen of this iron obtained from Dr Auerbach.

The principal mass although not altogether homogeneous, consists of iron, showing indications of Widmannstutian figures and imbedded in it pieces of meteoric stones with a large proportion of metallic iron disseminated through the same. The angular shape of the pieces and the irregularities of their borders leave not the least doubt as to their nature. They are real fragments, separated

from larger masses by mechanical force.

The uniformity of the fine-grained mixture of the fragments as well as that of the completely metallic nature of the inclosing mass corroborate this opinion. The density of a piece of the fine grained stone at 12° R was found to be 4.153; that of the iron as 7.332

Even before etching, but far more plainly afterwards three objects can be perceived on the surface of this iron. The greater portion of it is acted upon by the acids but projecting over it are figures in full luster, partly angular, partly made up of nearly parallel lines; the length of these ridges is at most four times, the width of the intervals between two is from one tenth of one line up to one line, the width of the ridges themselves is hardly one twentieth of a line. They are evidently Widmannstättenian figures, although they have not the regular arrangement

of those of Agram, Elbogen, Lenarto, Toluca, Durango. Similar to those of Bohumilitz the particles of Schreibersite are distributed in ridges along the separating lines of the individuals themselves, they even enclose granular particles made up of very minute individuals. This being the case is shown by the damask-like, although faint lustre of these planes. Besides the fine Schreibersite lines, the etching develops a brownish black lustrous silicate, sprinkled over the metallic surface like fine sands or in little fragments.

The Widmannstättian figures of the Tula iron show a striking resemblance to those of that of Burlington, Otsego Co N.Y., the latter however is far purer and especially without the fine sandy silicate.

The larger fragments of the enclosed meteoric stone are allied to those containing a larger

quantity of metallic iron, as for instance to that of Tabor, although the mass is of a dark brownish gray, almost a brownish black color; in the size of the grain it resembles the stones of Charsenville, although the greenish gray color of the latter is far more light. This truly remarkable stone has provoked discussion by the most learned men and I think it profitable to furnish the views which have been formed pro and con.

In 1863 this iron was fully examined by J Auerbach and after complimenting W Haidinger's researches he says; That an examination accurate and versatile as possible is very desirable the more so as from the doubt-expressed by competent parties whether the fragments of this stone were or were not in the state of scoria, which by later maltreatment of the iron in the forge fire would be compressed in it.

115
In order to remove completely such doubts I availed myself of a longer residence in Berlin under the direction of Rammelsberg to make a quantitative examination of the stones enclosed (amygdules) in the Tula iron. A lucky accident enabled him to cut through a specimen of the Tula iron that, in the interior, showed itself uncommonly rich in amygdules and exposed a plain Breccia in which the iron, piece by piece, was cemented together in angular fragments.

The amygdules appeared as very fine grained, dark gray, glittering homogeneous mass with numerous gray metallic scales or spangles enclosed. The piece employed for analysis weighed 3.1325 grms. The stone was reduced to pulverulent powder. The magnetic part (27.13%) was extracted by a magnet under water and the unmagnetic part (72.87%) was afterwards, each by itself, accordingly treated by widely known methods.

The result of the analysis of the magnetic part, in wt-amounting to 0.850 m.grms proved to contain. Iron oxyd 0.655 (or 0.4655 Fe); Alumina 0.077; Nickel 0.1545 containing cobalt^{*}; Magnesia with trace of lime 0.004

The portion insoluble in HCl (0.127 m.grm) consists of silicic acid 0.112 Chrome iron 0.035; Iron oxide with some alumina 0.012; Lime 0.0022, Magnesia 0.0023.

The Unmagnetic portion (2.215 grm) gave 1.943 m.grm (87.72%) decomposed silicate and in it
 Silicic acid 0.679; Iron oxyd 0.799 = $\begin{cases} 0.037 \text{ Fe} \\ 0.675 \text{ FeO} \end{cases}$

* The presence of a considerable quantity of cobalt as well as could be ascertained in the wet way - by means of Potassic Nitrite, as also could be plainly proved by the blowpipe, but the quantitative determination must, unfortunately, on account of a slight accident remain incomplete.

Alumina 0.163; Nickel 0.0065; Lime 0.0146

Magnesia 0.363; Soda 0.016

The undecomposed silicate on the contrary (0.272 = 12.28%) gave by expulsion with hydrofluoric acid, Silicic acid (lost) 0.1604; Alumina 0.057; Iron oxide 0.026; Lime 0.0025; Magnesia 0.0055; Nickel oxide 0.005; Soda 0.0111 Potash 0.0045 = 0.2720

The silicate decomposed and undecomposed by acid taken together had therefore the following composition.

Silicic acid 37.76; Iron oxide 31.64; Alumina 9.93; Lime 0.77; Magnesia 16.63; Soda 1.22; Potash 0.20 and besides this, contains mixed with it 2.13% of Nickeliferous iron.

From the mean of the silicic acid contained the quantity of the magnetic portion of the mechanically adhering silica was calculated and subtracted, by which it was proved

that the Nickeliferous iron (after deducting the 0.11% of chrome iron) from 72.14% of iron and 27.86% Nickel containing Cobalt consists of an unusually large amount of Nickel.

The percentage composition of the part of the silicate dissolved by the acid is calculated, after deducting the nickeliferous iron not completely removed by the magnet, to

A			Oxygen Ratio
			18.427
Silicio acid	35.49		
Oxide of iron	35.35	8.645	20.564
Alumina	8.52	3.982	
Slime	0.80	0.227	
Magnesia	19.00	7.595	
Soda	0.84	0.215	

Consequently the ratio of the oxygen of all the bases to the acid is as 10,282 : 9.213 or nearly as 1:1, entirely similar such as is seen for example in the Utrecht and Summer Co stones.

What is us is the exact prevalence of the magnesia and the iron oxyds in the bases authorizes the conclusion that the silicate consists essentially of Olivine.

The insoluble silicate has the composition

B	Silicic acid	58.97		Oxygen ratio 30.619
	Alumina	20.96		9.797
	Iron oxide	9.56	2.122	4.900
	Lime	0.92	0.260	
	Magnesia	2.02	0.800	
	Nickel oxide	1.83	0.389	
	Soda	4.08	1.047	
	Potash	1.66	0.282	

Also the oxygen in the silicic acid of the tria- and mona-atomic bases is 30,619:9.797:4.900 or almost as 30:10:6 = 3:1:1/2; that is, a bisilicate, in which the monatomic bases contain half as much oxygen as the triatomic. If we could calculate the quantity of the

Sabradorite from the alumina, then the largest part (72%) could be taken for it, by this means the rest of the large amount of alkalis would well correspond, for eventually of the Augite would scarcely exceed 28%

If we calculate from the preceding data the constituents of the anhydrides of the entire part we find them to contain Nickeliferous iron 16.70 Chrome iron 0.11 Olivine 72.98 Labradorite and Augite (?) 10.21 Iron Sulphide a trace = 100.00

"The principal mass of the Tula iron already proved by my former researches and by the mean of three examinations, there is found in it"

Schreibersite 0.90 Tin 0.07, Nickel 2.63

Iron 96.40. The quantity of schreibersite was too insignificant to prove anything but its approximate constituency, however, he reserves this research for a repetition of the Nickel determination, which especially in the comparison of the Nickel

contained in the metallic part of the stone appears to ^{be} quite too low an estimate.

Rammelsberg in an investigation of the same Tula iron observes after the following analysis by himself of the entire mass

Silicic acid 38.28 Alumina 10.05 Iron oxyd 32.46 Magnesia 16.91 Lime 0.81 Soda 1.24 Potash 0.25.

The silicate of Tula is so poor in silicic acid as to vary but little from a chondrodite, but is rich in alumina (Alessandria is uncertain)

And whilst the quantity of the silicate of the latter lies generally between mono and bisilicate it appears here as a monosilicate (Oxygen of R.O. and $Al_2O_3 : SiO_2 = 19.26 : 20.41$)

Also the decomposed part A (see page 207) though naturally likewise monosilicate (Oxygen 19.89 : 18.93) is not Olivine as Auerbach announces for it contains 8.5% of alumina and it was a

weak hypothesis to consider it as a representative of R.O.

The undecomposed part B (see page 119) expresses, whilst in A it lacked somewhat in SiO_2 and its quantity in the proportion is trifling, if possible a bisilicate (Oxygen of RO : Al_2O_3 : SiO_2 = 4.93 : 9.81 : 31 = 45 = 14.74 : 31.45 = 1 : 2.1) but nevertheless in no case would it be possible to find augite. In conclusion Rammeisberg observes that the nature of this silicate is still doubtful. It will be seen by comparing the observations of these three men that they disagree in some vital points. Haidinger disagrees with Auerbach in regard to the homogeneity of the stone. Rammeisberg and Auerbach differ in regard to the character of the silicates, particularly about Olivine. And they all agree as to the Widmannstätten figures. I base my classification of this stone upon Auerbach's conclusions.

RITTERSGRÜN

This stone was found near Schwarzenberg between John-George town and Eibens lock, sometimes called the Steinbach stone. Saxony.

Ohladni mentioned several iron masses of iron with olivine from Saxony. Such a one was described by Schumann in 1751, which Markgraf possesses and was found between Eibens lock and John-Georgetown upon a heap of iron at the rocky-brook machine works. A second piece was derived from von Schönbug's collection and is now the principal mass in Gotha (764.67 grms), it was labelled, "a curious piece of native iron, as found upon the field." In the de Drie collection such a piece occurs nominally from Senegal, in the Born collection such a one from Bohemia, in the Stieglitz an iron from Norway. All these iron show by their complete accord with that of Rittersgrün (known since 1861) that they

belong to the same fall and correspond to the iron of Steinbach. Distributed as follows.

Vierina 1K. 203.696 London 130.7 gr small pieces or such of unknown weight Berlin 50.146 grms.

Upsala 46.9 grms Göttingen 11.93 gr Stockholm (academy of science) as well as the private collections of Greg 17 grms. von Reichenbach, Neill, Shepard, Auerbach, Zimmerman in Hamburg, Trumman in Prag. Density of the iron 7.507 (Rumler) of Olivine 3.2759 (Stromeyer) 3.23 (Rumler) nominally that of Norway = 6.866 (Rumler)

Upon the cross section the iron appears in shiny tablets of different sizes and of different shapes from dark to blackish green Olivine

it shows especially rounded outlines and seldom has sharp edges. Etching produces the most beautiful Widmannstättenian figures which are however essentially different from those of Pallas, Uta-cama and Frahm irons. They are not, as this is,

surrounded by a thin edge, but by each particle of iron, that is surrounded by Olivine, the figures stretch out in like directions up to the outermost border there and appear also in the next particle again in like direction. By considering the figure from the three vertical cut surfaces standing one upon the other it can be plainly seen, that the entire iron mass is one crystal. Magnetic pyrites in particles varying from a hazel nut size to something very small is richly interspersed. Howard Analyzed the iron, that which came from the Born, in the Greville collection passed over and nominally derived from Tabor in Bohemia. He found, Iron 80 Nickel 20. Stromeyer examined the Olivine, the results of his analysis were

SiO_2	61.88	FeO	9.12	MgO	25.83	Mn_2O_3	9.37
Cr_2O_3	0.33	Loss by ignition		0.45	= 97.92		

The mass of iron of 86½ kg of Kittusgrün was

first made known in 1861 by Breithaupt; in 1847 it had been found by a peasant at a boggy place a yard (or less) deep in the ground. No smithy and no foundry in the neighborhood was able to use this "old iron".

Where it is not injured the mass has a thick crust of rust. The ignited crust is then and according to Breithaupt consists of magnetic iron stone, this could however have been formed by laying in the ground as that in the Tolucca iron.

By the complete resemblance which these irons bear to one another it is hardly doubtful that these localities belong to the same fall, as Rittersgrün and Steinbach are only one geographical mile away from each other.

The chief mass is in Freiberg, smaller pieces especially in Vienna, Berlin, and by Grg. von Reichenbach & Auerbach, were however no

large collection left.

Rube has analyzed the iron of Rittersgrün and found

Fe, 87.13 Ni 9.63 Co. 0.58 MgO. 0.15 CaO 0.25
P 1.37 SiO₂ 0.98

Gustave Rose says (p. 76) the olivine in the iron of Rittersgrün is found in small grains and which among one another are more heaped together and the granular particles united than the iron fall of Siberia is, where however it encloses the iron, it is crystallized and flatter than this. In the grains the color of the olivine is green, as in that of the Pallas iron, yet it frequently appears as brown by the commencement of decomposition.

Literature: Chladni. Feuermeteore p 324-326 mentions the different iron masses under different names, which Parlsch p 91 determined to be derived from the same locality.

Stromeyer. Pogg. Ann. vol 4. p. 196. Breithaupt Zeitschrift-

deutsch Geol. Gesellsch. vol 13. 148. Rube. Berg und Hütten. Ztg 1862, 72
+ Gustav Rose. Beschreibung + Eintheilung der Meteore. p 76.

ATACAMA

Found in the province of Atacama near the village of San Pedro in the beginning of this century; Imilac; in a field 100 leagues from the coast of Bolivia, 20 leagues north of the harbor of Cobiza, on the boundary line of Chili, South America. Philippin gathered a number of pieces in Dec. 1853. The largest piece seen by Philippin was about 25 kg and in the possession of Don Ign Domeyko. It had an irregular shape, with tolerably smooth surfaces and sharp angles; the elongated end is rough and crumpled and shows indications of octahedral crystallization. The mass is polar magnetic and the poles lie in the vicinity of the long ends. Philippin assumes from the path in which the piece lay that the meteorite came from the N. N.E. One part is fallen upon its path and then crushed; the smaller parts are scattered as sparks along the slope, whilst the larger pieces fell or rolled in the val-

ley. Specific gravity 6.687 Turner; 7.89 Field
7.663 Rumler 7.44 - 7.66 (the metal) Rumler.

3.33 (the olivine) Rumler; 7.736 (Potosi iron) Morren.

The smallest specimens have the form of thin leaves or sheets, the larger are more branching - papulose with rambling lines as upon paper, that is, ^{as if} knit together in the hand and again spread out. The upper surface is very black, one iridescent. The olivine in the cavities can be plainly seen, most of it is decomposed and changed into a whitish yellow or rusty red and earthy substance; under the microscope is revealed ~~the~~ vitreous or crystalline granules that consist of it. The cavities are quite regular, as if the iron had been squeezed in a melted condition between the crystals of olivine. The diameter of these cavities is seldom above 15 m.m and under 5 mm. The cross-section shows the iron with salient and reentrant angles and the olivine which

fills the cells is likewise angular seldom round

The polished surface shows iron sulphide in small quantities. The angular dark ground of the widmannstättian figures are surrounded by glittering borders and often interwoven by lines; the greater part of the edges lying near the particles retains its lustre. Many chemical analyses were instituted, particularly by Allan and Turner (1)

Frapoli (2) Field (3). Rivo (IV) Morren (V) von Kobell (VI) Schmid (VII)

	<u>I</u>	<u>II</u>	<u>III</u>	<u>IV</u>	<u>V</u>
Fe	93.40	88.01	87.80	90.40	90.241
Ni	6.62	10.25	11.88	8.60	9.759
Co	0.53	0.70	.....		
Mg		0.22			
Ba		0.13			
Na		0.21			
K		0.15			
P		0.33	0.30		
insol.	<u>100.55</u>	<u>100.00</u>	<u>99.98</u>	<u>0.30</u> <u>99.30</u>	<u>100.000</u>

	<u>VI</u>	<u>VII</u>
SiO_3	40.79	36.92
MgO	47.05	43.16
FeO	12.10	
Al_2O_3	0.02	
Fe_2O_3		17.21
Mn_2O_3		1.51
K_2O		0.59
	<hr/> 99.96	<hr/> 99.69

Trapoli analyzed a homogeneous looking small piece. Field found in the cavities of ^{the} surface small brownish white crystals of silicic acid, lime, iron oxide and phosphoric acid.

Von Kobell found no nickel, cobalt and manganese = protoxides and no arsenious acid as Rumler found. Schmid thinks the presence of nickel and arsenic doubtful. According to him Alecama and terrestrial olivine agree stoichiometrically.

Momn. Chron. Scientif 1 année No 8. Pogg. Ann. Vol 84 p 501. translated from German and French

Polysiderous - 1st-sub-Group

On the 26th of February, 1840, on the desert of Tarapaca, eighty miles northeast of Talcahuano, and forty six miles from Hualde; a meteoric iron mass was found by Mr Greenwood, Reporter of Tarapaca Mineral properties, and was afterward analyzed, in 1853, by Mr George Darlington of the Museum of Practical Geology with the following results: -

	a	b
Iron	93.41	93.48
Nickel	4.62	4.56
Cobalt	0.36	0.37
Manganese	0.20	0.18
Phosphurets	1.21	1.26
Chromium	<u>trace</u>	<u>trace</u>
	99.80	99.85

Its specific gravity is about 6.5 determined by R. P. Gregg esq. shows no crystalline figures, is honey-combed with cavities, and these contained pellets of lead some of them equal to the size of a pea.

Small quantities of alumina, phosphorus, and magnesia were found. This is the first authentic instance of the existence of native lead in meteoric bodies. see Phil. Mag. July, 1855. R. P. Gregg for a description.

The weight of the above was seventeen pounds.

Trickel Meteorite. from Oktibbeha Co. Mi. This unique meteorite was found in an Indian mound. It then weighed $5\frac{1}{4}$ oz, in shape resembled a hen's egg. When found there was a fissure that divided it almost equally in two parts. The person who discovered it seeing this, placed it upon an anvil and with one blow of a sledge-hammer, divided the meteorite. One half was forged, the other half remained in its original state, excepting that its exterior was filed smooth and bright. This meteor

it was examined by Mr J Taylor. It was proposed to have it cut by a lapidary, but he attempted it without success, using diamond dust on the wheel. On making the first incision, about one-eighth to one sixteenth of an inch in depth, he found it impossible to proceed, and refused to make farther attempts to cut the meteorite. Mr John Phillips, a fellow member of the Academy of Natural Sciences of Philadelphia, and an amateur machinist, succeeded, though with great difficulty in sawing it; it was peculiarly tough, the hardness not being excessive, heating the saw to such a degree as to oblige a discontinuance of the operation every four or five minutes, but it was remarkable that it did not dull the blade in the least.

The toughness of the iron was clearly shown when, for the purpose of analysis, it was attempted to cut off portions of it with a chisel.

the excessive toughness of the iron rendered this difficult without the aid of the saw. The resistance of this meteorite to the action of acids was most remarkable. Could not obtain the Widmannstätten figures. The color of the metal is a silvery grey with a pinkish tinge, it yields to a file. Its passivity was proved by its behavior toward neutral copper sulphate. The specific gravity at 25°Cels was found by Dr F A Genth to be 6.854, which is too low. The following is the result of Mr Taylor's Analysis

1.9421 grammes discolored in aqua-regia. 1.4731 gr of TiO gave of Ti 59.69%; 1.0452 gr of Fe_2O_3 gave of Iron 37.69%; 0.0221 gr CuO gave of Copper 0.90%; 0.0072 gr Al_2O_3 gave of Aluminium 0.20%; 0.0105 gr Co_3O_4 gave of Cobalt 0.40%; 0.0048 grm SiO_3 gave of Silicon 0.12%; 0.0069 grm 2MgO , P_2O_5 gave of Phosphorous 0.10%; 0.0057 gr CaO , Cl_2 gave of Calcium 0.09%, total 99.19. The slight loss of eight tenths of one per cent I think is owing to some

small portions of limonite existing in the minute fissures. The 0.10% of P. correspond to 0.64% of schreibersite ($P.Ni_2Fe_4$)

We must remain in doubt as to the exact locality where it was originally found, as it may have been carried by the Indians from a distance to be entombed in this mound, and it may have been considered by them to have a special value, and possibly to possess peculiar virtues from its being discovered in such a place.

Meteoric Stone of Borkut. This stone according to Dr Franz Sydolt, fell on the 13th of October 1852, at 3rd P.M., at Borkut in Hungary. It was found two feet underground and still warm. The largest-piece weighed 7 Vienna pounds, and 6 $\frac{1}{4}$ loths and the whole 12 pounds. The interior is ash-gray and irregularly fine granular. Its density is 5.242. It afforded 18.26% of magnetic material and 81.74 non magnetic. The former

former was found to contain, Iron 85.14, nickel (with some copper) 10.06, copper and tin, 0.40, sulphur 4.19. phosphorus 0.18 = 99.97. Separating 11.53 as FeS_2 the composition of the iron corresponds to Iron 87.96, nickel 11.38, tin & copper 0.46, phosphorus 0.20. The non magnetic part was partly soluble in HCl. The soluble and insoluble part-consisted of.

	SiO_2	Al_2O_3	FeO	CaO	MgO	K_2O	Na_2O
1. Soluble	36.16	3.07	21.43	1.20	36.34	0.50	1.27

The soluble part corresponds nearly to olivine; the insoluble to 34.93 % oligoclase and 65.59 pyroxene.

From these two analyses, there were excluded: from the first, before deducing the percentage, 0.82 FeS_2 and 13.09 nickeliferous iron; from the second 1.60 chromic iron.

- Hommony Creek, near base of Pisgah Mountain (ten miles west of Asheville) Buncombe Co N. C. This mass weighed nearly twenty seven

To Face page 138

Hommonoy Creek

pounds. Its surface is rather tuberosse and jagged than pitted with regular depressions. The fresh fracture has a color and lustre intermediate between steel and magnetic iron pyrites. It is malleable and heterogeneous. Analysis by Shepard.

Iron with traces of Cr and Cobalt-98.19 Nickel 0.23
Carbonaceous matter, insoluble matter and loss 1.58

Specific gravity 7.32. Hardness variable. Examined, described and analyzed by Clark also, Analysis

Iron 93.225 Nickel + Cobalt-0.236 Copper and tin 0.099
Manganese(?) Silicon 0.501 Magnesium(?) Phosphorus(?)
Sulphur 0.543 Graphite, schreibersite $4.765 = 99.369$

The accompanying sketch shows its surface structure.

- Claiborne Clark Co. Alabama. This mass was found by Mr. Hubbard near Limestone Creek. It was of an irregular triangular shape, rounded at the corners and was ten inches long by 5 or 6 inches in thickness, the rounded surface is coated with a thin layer of ferrous chloride, which is found

129
to conceal the mass of metallic matter

Several fragments have broken off and determined separately.

Specimen 1. weighed 25 grains, Density 5.75 yielded 16.296 grs of metallic iron, + 6.927 grains metallic nickel these corresponded to 65.184% of Fe and 27.708% Nickel. In Specimen 2. having density of 6.5 in 50 grains we have

Iron 33.280 grs, or 66.56%; Nickel 12.354 grs or 24.708%. Chrome and Manganese 1.625 grs or 3.240%. Sulphur 2. grains or 4%; Chlorine .74 grs or 1.48%. total 49.999 grs or 99.988%

The two remarkable features of this mass is its large percentage of nickel and the presence of chlorine, though it is not impossible for the chlorine found to be of terrestrial origin; the above analysis is the work of Mr Charles Jackson.

- Cooke Co. Tennessee

Density 6.222 Fell

Prof Shepard obtained fragments of it and his results are, from

	10 grains	30 grains	50 grains
Iron	93.80	94.033	93.80
Nickel	4.66	4.444	4.66
Insoluble residue	.10	.100	
Carbon			.10
Silicon			
Phosphorus + grains of Fe + Manganese			
Oxygen, Fe SO ₄ , S. H ₂ O & loss			1.44
	<u>98.56</u>	<u>98.477</u>	<u>100.00</u>

BITBURG

Province of Niederrhein, Prussia, found 1802, known since 1814. The original iron mass was about 1600-1700 kg in weight, 1802 $\frac{3}{4}$ german half miles from Zittun upon a smaller elevation a foot deep in the ground. In 1807 the greatest part was melted at the Pluvinger forge near Trier. Malleable while cold and and red short.

It does not form lumps, as many common ones are alloyed with. Therefore it was thrown away and hidden. Later, first in 1833, it was again searched for and excavated. It occurs that there are only a few collections which have pieces of the iron found originally, namely in Vienna 108. 281 grms, Berlin 10. 329 grms. Trier, Society Natural Inquiry about 24 grm. New Haven 32 grm. The unfused portion on the contrary is widely diffused, especially in Göttingen, Utrecht, Paris Mus. Natural History, London, Gießen, Florence, Frankfurt, on the Maine. Würzburg. Leipzig.

Heidelberg, Bern and the private collection of Erzherzog Stephan von Schaumburg, of Prince Lobkowitz in Berlin. Krill, Neumann, von Reichenbach, Zimmermann, Auerbach, Greg, and Fischer in Hamburg. It has the decided appearance of a furnace product, and in the interstices slag is found and even large grains of carbonaceous matter.

This is lacking in the original iron. On the contrary this contains many small grains of a yellow substance, and in it a brown or greenish appearing substance like olivine. On the etched polished surface the Widmannstätten figures were very plain.

Density 6.14 Steininger 6.52 Rumler (both unfused) 6.679, + 6.859 Jørgensen and Bischoff (both fused) The presence of nickel was at first discovered by Gibbs and confirmed by Bischoff and Karsten.

Complete analyses are furnished by Stromeyer I. and by John II.

	^I	^{II}
Fe	81.80	78.82
Ni	11.90	8.10
Co	1.00	3.00
Mn	0.20	4.00
Si		0.80
S	5.10	4.50
SiO ₃		5.50
	<hr/> 100.00	<hr/> 104.72

John found Al_2O_3 and Fe_2O_3 ; he discovered traces of Selenium.

Literature. *Gilt. Ann.* v. 60 p 243 + v 68 p 342
Bischof Schwigg Journ. v 43 p 11 v 46
 p 385, 392.

Translated from the German

Oligosiderous 2nd sub-group

In October, 1869 (the 6th) there fell in Stewart Co Ga a meteoric stone. It was examined by J. Lawrence Smith, when he obtained it, it weighed $12\frac{1}{4}$ oz. and he thinks it must originally have weighed $12\frac{1}{4}$ ounces. Its specific gravity is 3.65. The fractured surface has a grayish aspect, and when examined closely, especially by the aid of a glass, exhibits numerous greenish globules with a whitish granular material between; through the mass are dark particles consisting principally of nickeliferous iron with some pyrites and a few specks of chrome iron. The nodules are sometimes three or more millimetres in diameter, and of an obscure fibrous crystalline structure, the crystals

radiating usually from one side of the nodule; they have a dirty bottle-green color, a greasy aspect-when broken, and are more or less opaque. Some of these little nodules were separated in a tolerable state of purity amounting to 121 milligrams; on analysis they afforded:

		Oxygen	Ratio
Silica .	48.62	25.90	2.
Alumina	8.05	3.79	
Protoxyd. of iron	11.21	2.51	1
Magnesia	30.18	11.80	
	<hr/> 98.06		

Nickeliferous iron constitutes about 7 percent of the mass and a portion separated in as pure a state as possible, afforded on analysis-

Iron	86.92
Nickel	12.01
Cobalt	<hr/> 0.75
	99.68

An analysis of the stony part, omitting the

nickeliferous iron resulted thus.

The part soluble in acid 58.05

The part insoluble in acid 41.95

	Soluble part.	Insoluble part
Silica	41.08	56.03
Alumina	0.32	5.89
Protoxide of Iron	18.45	15.21
Magnesia	41.06	21.00
Lime	---	0.10
Soda with a little K. & Li	—	<u>2.97</u>
		101.20

Chrome iron was detected by fusion with Na_2CO_3 and KNO_3 . The composition of the stone as made out would be,

Nickeliferous iron	7.00
Magnetic pyrites	6.10
Bronzite or hornblende	}
Albite, Albite or oligoclase	
Chrome iron	
	<u>86.90</u>
	100.00

Meteorite Stone from near Mainz. — The date of fall — Locality, Mainz. Density 3.44 hardness 5. The analysis by F. Seelheim afforded, soluble gelatinizing silicate 52.23%. insoluble silicate 39.26% other ingredients 8.50

Soluble gelatinizing silicate consisted of SiO_2 15.74, MgO 16.12 Al_2O_3 2.08 FeO 18.29 Oxygen ratio of silicates for R^{I} : $\text{Si}^{\text{I}} = 10.94 : 8.17$

Insoluble silicate (39.26%) SiO_2 20.96, Al_2O_3 13.49, FeO 3.60 K_2O 1.21 Oxygen ratio for R^{II} , R^{III} : $\text{Si}^{\text{II}} = 1 : 6.3 : 10.9$

Other ingredients (8.55%) FeS_2 3.86 Nickeliferous iron 2.13 Cr_2O_3 0.46 P_2O_5 0.60 H_2O 1.51, Cu Sn Mn CaO traces. It is granular.

The Searsmont Meteoric Stone, Maine.

Its fall occurred about 8 o'clock May 21 - 1871 nothing is plainer than the distinction in character between the upper sides and the base. The crust of the latter is black, more thoroughly fused, with a bubby, somewhat glassy

reticulated surface, whose lines are without any order, while the upper surfaces are more even. The stone is rather below the average in respect to fragility. The color is bluish white, uniform except from occasional stains of FeO. More than half the stone is in the form of rounded grains, mostly with roughened or drusy surfaces, and of size of mustard seeds. Minute points of bright-meteoric iron are thickly scattered through the mass. Density of the mass 3.626 (Shepard)

It resembles the Mauerkeichen stone that fell in 1768. The Density according to J. L. Smith is 3.701. The nickeliferous iron & stony matter were separated mechanically for analysis, one hundred parts of the meteorite gave.

Stony matter (including FeS.) 85.38

Nickeliferous iron 14.62

100.00

The iron afforded, From 90.02, Nickel 9.05
Cobalt-.43 = 99.50 Phosphorus and Copper
were not-estimated. The stony part treated
with a mixture of hydrochloric and Nitric
acids gave Soluble in acid 52.3 Insoluble
in the acid 47.7. The soluble portion afforded
Silica 40.61, FeO 19.21, MgO, 36.34. FeS 3.06
Leaving out the sulphide which is obviously a
mechanical mixture, this soluble part is
evidently an olivine, — which is almost
invariably the case with soluble portions of
meteoric stones. The insoluble part afforded,
Silica 56.25, FeO 13.02, Al₂O₃ 2.01, MgO
24.14, Alkalies Na₂O, K₂O with trace of Lithia 2.10
Chrome iron, small black specks, not estimated = 97.52

The above analyses give for the composition
of the stone;

Nickeliferous iron 14.63. Magnetic pyrites 3.06
Olivine 43.04, Bronzite, a hornblende, with a

little albite or orthoclase $39.27 = 100.00$

The meteoric stones at New Concord, Ohio, May 1st, 1860. The largest stone weighed 103 lbs. The larger stones were carried by the orbital force further than the small ones. All are coated with a black crust and show a bluish-grey feldspathic interior with numerous brilliant points of nickeliferous iron. Fig 1 in the sketch shows the appearance of the larger one in the cabinet of Marietta College. Fig 2 shows at A the angle of one of the stones, the dotted line shows the thickness of the crust. Fig. 3. represents the appearance of a small stone. Metallic grains are quite numerous. Specific gravity of the stone examined by D. M. Johnson was 3.5417. An analysis one gram of this stone yielded,

Silica .51250, FeO .25204, MgO .08873, Alumina .05325, CaO .00785 Iron .08803 Nickel .02360 Sulphur .01184 Chromium trace, Phosphorus trace

Water, $0.0035 = 1.03814$

-The stones of Harrison Co. Indiana. Fell
March 28th 1859. The following stones were
discovered

No 1. weighing 19 oz discovered by Goldsmith

No 2 " 4 1/2 oz " " Crawford

No 3 " 420 grains " " Lamb

No 4 " 167 " " " Mrs Kelley

No 1, 2 & 4 are cuboidal in shape. No 3 was
considerably elongated. They are all covered by a
black vitrified surface, when broken show the
usual grey color of stony meteorites interspersed
with bright metallic particles. The mean density
is 3.465. Examined as a whole the following
elements are found in it: iron, nickel, cobalt,
phosphorous, sulphur, silicium, calcium, alum-
inum, magnesium, manganese, sodium,
potassium, oxygen.

By the action of the magnet it was

separated into

Nickeliferous iron 4.91, earthy minerals 95.19 = 100.00

The soluble portion consisted of 62.49% & the insoluble of 37.51. The metallic portion separated from the earthy part gave,

Iron 86.781, Nickel 13.241, Cobalt-0.342. Copper .036 Phosphorous .026 Sulphur .022 The earthy portion freed from metal gave

Silica 47.06, Oxid iron 26.05. Magnesia 27.61
Alumina 2.35. Lime 0.81. soda 00.42 Potash
00.68, Mu_3O_4 ~~00.68~~ trace not-estimated
= 94.98 Its mineral characteristics range

about the following proportions,

Nickeliferous iron 4.989, Schreibersite .009

Magnetite pyrites .001 Olivine 61.000, Pyroxene
and albite 34.000 = 99.999

- In Moravia - Fell on the 25th of Nov. 1833. Density
Wright- According to Berzelius,

in one hundred parts there are 17.15 of meteoric
iron, separable by the magnet, containing Nickel
Cobalt, tin, Copper, sulphur and phosphorus

- 42.67. silicate of magnesia and Ferrous oxide
in which the silica and base contain equal
quantities of oxygen and FeO. — 39.43 magnesian
silicate and ferrous oxide, mixed with potassium
silicate, Calcium oxide and Aluminic oxide in which
the silica contains twice as much oxygen as the bases.

- 0.75 chromate of iron + oxide of tin.

100 parts of the iron contain

Iron, 93.816, Nickel 5.053 Cobalt 0.347, Tin and
Copper 0.460 Sulphur 0.324 and a trace of phosphorus.

- 100.000, The remaining or stony portion of the
mass is partly soluble, the soluble part consists

of
Silica 33.084, Magnesia 36.143 FeO 29.935. Oxide of

manganese 0.465, Oxide of Nickel containing tin and copper 0.465, Alumina 0.329 Soda 0.857 Potash 0.429 Loss, principally sulphur 1.273 = 100.00 The insoluble part contains, Silica 57.145 Magnesia 21.843 Lime 3.106 Ferrous oxide 8.592, Oxide of manganese 0.724 Oxide of Nickel, containing tin and copper 0.021 Alumina 5.590 Soda 0.931 Potash 0.010 Chromate of iron, containing tin 1.533 Loss 0.505 = 100.00.

- Linn Co., Iowa. for drawing of this see vol 15, 1853 See *Annals* p 6.

This fall was in two pieces, the exact weight of the larger piece is not known, the smaller piece weighed 21 lbs and 7 oz. The homogeneity of the earthy portion is the remarkable feature of this stone. The proportion of the mineral ingredients of this stone approach the following,

Howardite, 83.00, Nickel-iron 10.44, Magnetic pyrites 5. Olivoid and anorthite in traces = 98.44

The powdered stone freed from nickel-iron af-

Concord, CHIC.

forded

Silicic acid 60.16, Ferrous oxide 23.50 Magnesia
11.20 Magnetic pyrites 4.66 Soda and potassa
0.30 = 99.82 Lime and Nickel in traces.

- Forsyth, Ga. Fell

Wright- Density 3.52 According to Shep-
ard it contains the following ingredients-

Nickel iron 10. Howardite 70. Olivinoid & Anorthite
10 to 15 Magnetic pyrites 2 to 5. Upatite in traces.

The nickel iron consists of

Iron 89.00 Nickel 9.60 Chromium & loss 1.40 = 100.00

The earthy portion of the stone afforded,

Silicic acid 50.00, Ferrous oxide 33.33 Magnesia
9.30. Lime 5.30. Alumina 1.80. = 99.73.

- New Concord Ohio.

This fall occurred on May 1st 1860. Weight of one
of the stones $36\frac{1}{2}$ pounds. Density 3.5417. All
are coated with a black crust and show a bluish
gray feldspathic interior with numerous brilliant

points of nickeliferous iron. Its analysis by D. M. Johnson afforded Silica .51250 Ferrous oxide .25204 Magnesia .08873 Alumina .0325 Lime .00785 Iron .08803 Nickel .02360 Sulphur .01184 Chromium, trace; Phosphorus, trace; Water .00035 = 1.03819

- Chateau - Renard.

A fragment of the meteorite which fell near Chateau-Renard, in France June 12, 1841, has been examined by M. Dufrénoy. The meteorite appears to have burst, at an elevation which cannot be determined, into several pieces of which two only were seen to fall on the earth, about forty paces apart. One of these pieces falling on a rock was broken into a multitude of fragments; the other buried itself to a depth of about 20 centimètres, and has separated into but a few fragments, of which the largest is 35 centimètres and 11 centimètres wide. Its fracture is granular, a small vein runs

through the whole mass. Externally is of a dark gray color and is composed of crystalline portions which cross each other as in the volcanic porphyries. The density of the stone is 3.38, of the grains of metallic iron, extracted by the magnet-is 6.48.

M. Dufrenoy gives the following as the result of three analyses which he made.

Silica 38.13 Magnesia 17.67, Ferrous oxide 29.44
Manganese dioxide a trace, Alumina 3.82,
Lime .14, Metallic iron 7.70 Nickel 1.55 Sulphur .39
Potash 27 Soda .86 = 99.97

Or grouping together the elements which are combined

Alloy of iron and nickel 9.25 Pyrites .67

Ferruginous peridotite, soluble in acids 51.62

Matter insoluble in acids, and not related to any known mineral 38.17 = 99.71

— Cabarras Co. N. C.

This fell October 31st - 1849. The entire stone now weighs about $18\frac{1}{2}$ lbs. The general figure is that of a low, irregular, four sided pyramid, truncated at the summit, and having for a base a somewhat rounded, undulatory surface. The crust is thin, black and strongly coherent. It is exceedingly tough; in this respect fully equalling most trappean rocks. Its ground color is of a dark bluish-grey, stained with fine rust-points, and mottled with rounded grains and crystals of a lighter colored mineral, rendering the mass when closely viewed, sub-porphyrific. Density = 3.60 - 3.66

It consists of according to Prof Shepard,
 Nickelerous iron, (with chromium) 6.320
 Magnetic pyrites 3.807 Silica 56.168. Protox Iron
 18.108, Magnesia 10.406 alumina 1.797
 Traces of lime, soda, potash and loss 3.394

= 100,000

-Alacama Province, fifty miles from Copiapo Chile. Described by Joly in 1864. Its weight-uncut was 1784 grammes. Density, Joly, 4.35. A polished etched surface gave an impression on paper of scattered points rather than of regular lines. Active. Contained a large amount of stony matter interspersed through the mass. The color and hardness of a portion of this indicated olivine; other fragments recalled the appearance of partially decomposed labradorite.

Nickel and Cobalt were separated by the method of chlorine and carbonate of baryta. Analysis by Joly.

Fe 77.48 Ni 7.77 Co 1.23 Mn 0.55 CaO 1.80

Al₂O₃ 5.02 S 3.95 P 0.17 Cu 0.06 SnO₂ 0.04 = 98.07

The soluble portion affords, by assuming 1.90% O

Fe 70.83 Ni 7.77 Co 1.23 Cu 0.06 S 3.95 P 0.17 Mn 0.55

Al₂O₃ 5.02 FeO 8.55 CaO 1.80 SnO₂ 0.04 = 99.97

The average of several analyses gave 68.19 % soluble in acids and 31.81 % insoluble in acids.

The insoluble mineral portion, Result from
0.518 grms.

SiO₂ 64.478, FeO 14.073 MgO 13.005 MnO 3.239
Cr₂O₃ 1.750 - 2.575 Cr₂O₃ FeO; Al₂O₃ 1.144 CaO 0.864
SnO₂ + CuO 0.965; NiO, CoO 0.386 = 99.904

2nd Analysis. 1.114 grammes

SiO₂ 65.61, MgO, 13.90 FeO 14.78 Cr₂O₃ 1.25 Al₂O₃ 1.07
MnO 2.91 CaO 1.15 NiO, 0.09 = 100.76

Mean

SiO₂ 65.04 MgO 13.45 FeO 14.42 Cr₂O₃ 1.50 Al₂O₃ 1.10
MnO 3.07 CaO 1.01 NiO 0.23 = 99.82

From these analyses the composition of the entire
stone is

Fe 48.298 Ni 5.298 Co 0.838 Mn 0.375 Cu 0.040
S 2.693 P 0.115 SiO₂ 20.689 insoluble MnO 0.976
insoluble Cr₂O₃ 0.477 insoluble, NiO CoO 0.073 insoluble
FeO 5.830 soluble FeO 4.587 insoluble CaO 1.227 soluble
CaO 0.321 insoluble Al₂O₃ 3.423 soluble Al₂O₃
0.349 insoluble MgO 4.278 soluble SnO₂ 0.027 soluble

SnO_2 0.162 insoluble

Metallic portion; Fe 48.298, Ni 5.298 Co 0.838 Mn 0.375

Cu 0.040 S 2.693 P 0.115 = 57.657 Mineral portion;

SiO_2 20.689 MnO 0.976 Cr_2O_3 0.477 NiO, CoO 0.073

FeO 10.417 MgO 4.278 Al_2O_3 3.772 CaO 1.548 SnO_2

0.189 = 42.419 In 100 parts

Metallic Fe 83.76 Ni 9.18 Co 1.45 Mn 0.65 Cu 0.07 P 0.20

S 4.67 (12.84 FeS) = 99.98 Mineral = ; SiO_2 48.61

FeO 24.47 MgO 10.05 Al_2O_3 8.86 CaO 3.63 MnO 2.29

Cr_2O_3 1.12 NiO, CoO 0.17 SnO_2 0.44 = 99.64

The mineral portion is thus constituted

Chrome iron 1.64 Cr_2O_3 FeO; Olivine 27.43 Labradorite

70.13 = 99.20 This will give for the composition of the meteorite

Nickel iron (with Co, Mn, + Cu) 48.689 Iron sulphide

7.405 Chrome iron 0.701 Schreibersite (Fe 1.38 Ni 0.67

P. 0.115) 1.563 Olivine 11.677 Labradorite 29.852

Tin stone = 0.189 = 100.076

- Guernsey Co. Ohio. Fell May 1st-1860. Discovered by D. Mackley. Wm C. Willes and others. Described by J. Lawrence Smith 1860. Density Smith 3.550

Analyses by Smith. In 100 parts

Nickeliferous iron 10.7 Earthy minerals 89.3 = 100.00

The nickeliferous particles separated by a magnet from the crushed stone and well washed gave

Iron 87.011 Nickel 12.360 Cobalt 0.421 Phosphorus 0.012

Sulphur 1.080 Copper not estimated = 100.884

Earthy portion; Soluble matter 63.7 Insoluble 36.3 = 100

The earthy material analyzed as a whole gave

Silica 47.30 Oxide of iron 28.03 Alumina 0.31 Magnesia 24.53 Lime 0.02 Soda and Potash 1.04

Manganese trace = 101.23 The minerals

contained in it are Nickeliferous iron 10.690

Schreibersite 0.005 Magnetic pyrites 0.005 Olivine

56.884 Pyroxene 32.416 = 100.00. Its interior exhibits

a grey mass with metallic particles of nickeliferous iron. There are twenty four of them.

Newton Co. Arkansas Fine of fall
 Discovered 1860 Described 1865 Density Smith 4.5 to 6.1
 Analyses by J. Laurence Smith.

Nickeliferous iron

Iron 91.23 Nickel 7.21 Cobalt .71 Copper and phosphorus not estimated = 99.15 The minerals separated by mechanical means are Nickeliferous iron, Chrome iron, Ferric sulphide, Hornblende, Olivine and Carbonate of Lime.

The chrome iron is found in small quantities. Sulphuret of iron in small quantities Hornblende, composition

Silica 52.10 Alumina 1.02 FeO 16.49 MnO 1.25

Magnesia 29.81 Alkalies - (potash, soda, lithia) = .24 = 100.91

Olivine, gave Silica 42.02 Alumina 0.46 FeO 12.08

Magnesia 47.25 = 101.81

Some Carbonate of Lime was found but this is believed to have formed by exposure to the action of the air and not of celestial origin.

- Fultehpore Hindostan. Fell Nov 30, 1822, seventy two miles from Alla hatad on the Cawnpore Road in lat $25^{\circ} 57'$ N and long $80^{\circ} 50'$ E. A number of stones, largest weighed 22 lbs another weighed 2 lbs. Density Shepard 3.352 Density at -17° R Staidinger 3.526. It belongs to Reichenbach's whitish meteorites, 2nd family. 1st group.

The mass is pale ash grey, fine grained and on the fracture planes it shows yellowish brown spots of so called iron rust, vein like plates of pyrites of a reddish bronze yellow color pass through the mass, the polished surface shows many particles of metallic iron, the largest oblong grain was $1\frac{1}{2}$ lines long and one line broad. Described by Staidinger and Shepard.

III Group.

Cryptosiderous 3rd. Sub Group

This mass of meteoric stone fell two miles west of Petersburg in Lincoln Co Tenn, at about half past three P.M., Aug. 5th, 1855, during, or just before, a severe rain-storm. At first it weighed three pounds. The specific gravity of the entire mass is 3.20. The nickeliferous iron forms about one half of one per cent of the mass. The general analysis affords.

Silica	49.21
Alumina	11.05
Protox iron	20.41
Lime	9.01
Magnesia	8.13
Manganese	.04
Nickel & Phosphorous	trace
Iron	50
Sulphur	16
Soda	83
	<hr/> 99.23

The fresh fracture has an ash grey color, with a slight intermixture of pearl-grey, for the basis of the stone. The above analysis is by J. L. Smith.

The stone breaks with more than the usual facility of meteoric stones. The specific gravity of fragments is 3.23. The nickeliferous iron, separated by the magnet, amounted to 2.5%. On treatment with hydrochloric acid the stony mass afforded,

Alumina	13.00
---------	-------

Silica	4.00
--------	------

Peroxide of iron	1.80
------------------	------

Magnesia	5.0
----------	-----

The following is an approximation to its mineral character.

Anorthite	82.0 %
-----------	--------

Chladnite	9.0
-----------	-----

Olivine	5.0
---------	-----

Pyroxene	1.0
----------	-----

Nickeliferous iron	2.5
--------------------	-----

Chromites and Pyrites	$\frac{0.5}{100.00}$
-----------------------	----------------------

167

Lincoln Co ^{Tenn.} Kentucky. Fell two miles west of
Petersburg and fifteen miles northwest of Fayetteville
about half past three o'clock P.M. Aug 5th 1855.

Described by J. L. Smith 1861 Density, Smith, 3.20

Analysis by Smith.

Silica 49.21 Alumina 11.05 Protoxyd of iron 20.41

Lime 9.01 Magnesia 8.13 Manganese .04 Iron .50

Nickel minute quantity Phosphorus minute quantity

Sulphur .06 soda .82 = 99.23 This specimen has

an edge broken off revealing an interior of ashen
gray color varied by patches of white yellowish and
dark minerals. Dimensions, base $2\frac{3}{4} \times 2\frac{1}{2}$ inches

Base to apex $4\frac{1}{2}$ inches. Three adjacent sides are rough
being covered with cavities and pits. The other sides are
smoother and rounded. The specimen acts on the

needle Its weight is 3 lbs., 14½ oz. Minerals found in
it are Pyroxene, Olivine, Orthoclase and Nickelif-
erous iron.

- The Cold Bokkeveld Meteorites.

These fell at Cold Bokkeveld, near the Cape of Good Hope, October 13, 1838. Specific gravity is 2.94. The stone is stated as being soft, porous and hygroscopic, possessing a very small degree of magnetic power irregularly dispersed through it.

According to Sir Michael Faraday the stone yielded
Water 6.50, Sulphur 4.24, Silica 28.90, FeO 33.22

Magnesia 19.20 Alumina 5.22, Lime 1.64

Oxide of Nickel .82 Chromic oxide .70 Borax and Soda, a trace = 100.44.

- Richland South Carolina.

This mass fell in the summer of 1846. The stone was almost round, $2\frac{1}{10}$ inches in diameter, and weighed $6\frac{1}{2}$ oz. The exterior was coated by a dark reddish brown glaze. The interior presented the fracture and color of ordinary fire-brick. Density 2.32 It consisted of according to Prof. Shepard
Silica 80.420 Alumina 15.680 Protox of iron 2.513

Magnesia 0.700 Lime 0.500 = 99.813

No examination was made for the alkalis.

Analysis by Rammelsburg

Si 70.42 Al_2O_3 20.25 Fe_2O_3 3.86 MgO 4.47

CaO 1.21 Ign. 1.28 = 100.49

Rammelsburg found that Hydrochloric acid had very little action on the substance. He considers it as ferruginous clay and suggests that perhaps it is a fragment of a brick.

Guirnas.

This remarkable stone fell at near Libonnetz
Dép. de l'Ardeche, Languedoc France, on the
15th of June 1821 between 3 and 4 o'clock P.M.

A large stone 110 kg and in the neighborhood
several others. The largest fragment of 42 kg is
in the museum of Natural history at Paris, there
are smaller ones in several collections London
1.027 kg. Berlin 1.023657 kg. Vienna 698.373
gr. (4 stones) the largest 498.762 grm Leipzig 151.272 grm

Göttingen 151 gm. Edinburgh 130 gm. Darm-
 stadt 45.47 gm. and still smaller in Fries,
 Hudson, Stuttgart, Stockholm, Calcutta. In
 private collections there are, van Breda in Harlem
 801.3 gm. Shepard 312 gm. Greg 194 gm.
 von Reichenbach, de Ly Luyres 32.4 gm and a
 piece by courtesy to Autenas, Dep Ardèche, July
 1821, that belongs here and was found later
 of 248 gm. Density 3.099 (D. Hombres Firmas)
 3.148 (Rumler)

The crust is very thin, black lustrous, veined
 massive and hard, now and there with brown
 spots. The interior is very similar to the dolerite
 of Meissner, it is a granular, quite friable mix-
 ture, in particular a brown or dirty dark green
 and ~~quite~~ white constituents in equal portions,
 which appear in crystalline, angular grains
 and scales, between these are straw yellow sheets
 which in many places are entirely wanting.

In small cavities and holes are found crystals of a brown substance with measurable angles and which appear to be augite. The white mass appears in places while in still larger portions and shows a very plain laminated fracture, but the crystals in the cavities are mostly too small to be measured. Hauy and Saugier regard it as feldspar; according to G. Rose it is probably Labradorite, according to Shepard and Rammelsberg, Anorthite. The brownish green thin tabular crystals (more than an inch long) is called Phenocrite, it occurs ^{equally} with augite and feldspathic stones. Particularly upon the polished surfaces it can be perceived that in one place the ingredients are separated by somewhat coarse grains and are in round or elliptical particles.

The early analysis of Vauquelin (I) and Saugier (II) are incomplete.

c-7

	I.	II	III	IV
SiO_2	40.00	40.00	44.38	52.07
Al_2O_3	13.40	10.40	33.73	0.24
Fe	27.00			$(\text{FeO}) = 30.81$
Mn		(MnO) 6.50	$(\text{P}_2\text{O}_5) = 0.54$	$(\text{TiO}_2) = 0.16$
Fe_2O_3		23.50	3.29	$(\text{FeO.Cr}_2\text{O}_3) = 2.13$
CaO	8.00	9.20	18.07	5.68
MgO		0.80	0.36	9.98
MnO			1.03	0.41
S		0.50	$(\text{FeS}) = 0.71$	
Cr	11.6	1.00		
Cu		0.10		
K_2O		0.20	0.33	
	100.00	92.2		

Analyses III and IV are by Rammelsberg and are accurate and reliable. Analysis III is the soluble portion (36.77% of the whole) and IV is the insoluble portion (63.23%). According to Rammelsberg the stone consists of about 36% Anorthite, 60% Augite, 1.5% Chromic iron + 0.25% pyrrhotine or magnetic pyrites and perhaps small quantities of apatite and

Titanite. Rammelsberg did not find copper.

Nickel was not found in any analysis. According to Bunsen's spectrum analyses Lithia was discovered.

Very singular is the large quantity of lime and alumina, whilst the amount of magnesia is very small.

The above account is translated from the German of Dr Otto Buchner's work on meteorites.

Literature. Vauquelin. Gilbert Annalen. vol 71 p. 202. Saugier, do vol 71, p 208. G. Rose Annalen vol 4, p 174. Rammelsberg, do, vol 73, p 585. Wöhler Annalen der Chemie und Pharmacie Nov 1861, p 253.

IV GROUP

ASIDEROUS

On the 22nd of December 1868 Mr Benjamin Pybas stated that an aerolite weighing $1\text{ lb } 9\frac{1}{2}\text{ oz}$ had fallen four miles south of Frankfort in Franklin Co., Ala., on the 5th of December. The stone was sent to Mr Geo J Brush of Yale College and when received by him weighed 615 grams. On the fractured surface, it presented a pseudo-porphyrific structure having a grey ground with black, green, white and dark grey spots upon it. The latter were brilliant points with metallic lustre which proved to be sulphide of iron.

The specific gravity of the stone in four determinations gave 3.35, 3.33, 3.31, 3.26 the mean being 3.31. The analysis was commenced by Mr Brush but was finished by Mr Wm G. Miller, and with

FRANKLIN Co. ALA.

the following results.

		Oxygen	
Silica	51.33	26.37	
Alumina	8.05	3.75	
Ferrous oxyd	13.70	3.04	
Chromic oxyd	0.42		
Magnesia	17.59	7.04	12.28
Lime	7.03	2.06	
Soda	0.45	.11	
Potash	0.22	.03	
Sulphur	0.20		
Nickeliferous-iron	<u>trace</u>		
	99.02		

The accompanying drawing will give an approximate idea of its general appearance.

Shalka, or Shaluka, in Bancoorah Hindostan
fell about 80 yards south of the village in a rice-
field on the 30th of Nov.; 1850 three hours before
sunrise. The fall was witnessed by two persons
Described 1860 The real fracture shows greasy lustre.
The mass is extremely friable and fragile
H. 6.5 Density at 19° R. Haidinger = 3.412
Small grains up to the size of a millet-seed of
chromic iron, sometimes in octahedral crystals
are intermixed with the ash-colored mass. The
dull blackish brown crust is not thicker than
writing paper; here and there it forms irregular
reticulated particles, which show somewhat more
lustre.

It does not contain any metallic iron. The grey mass
contained according to K. von Stauer. Silicic acid 57.66 Alumina
trace Oxide of iron 20.65 Lime 1.53, Magnesia 19.00 = 78.84

This meteorite belongs to Richenbach's first-family (?) first-
group & Shepard's Chladnitic-brachytic stones.

- Bishopville S. C. Fell on the 25th of March 1843. Described in 1846. Originally weighed 13 lbs. Contains no metallic iron.

The composition of the snow white mineral (constituting about 90 p. ct of the entire mass) as given by Prof. Shepard is,

	Oxygen	Ratios
Silica 70.41	35.205	3
Magnesia 28.25	11.300	1
Soda 1.39	0.338	

From the results of this analysis he considered it as a tersilicate of Magnesia, constituting a new species to which he gave the name of Ehladrite. It shows itself throughout the cavities and it appears as if ^{galled in} many places by exposure to the atmosphere. Densely, Shepard, 3.116

After Shepard, Sartorius von Waltershausen engaged in the study of this white mineral.

The former observed the uniaxial crystals in some parts nearly as large as one inch whose forms

are found in the common feldspar group but their surfaces are rough and not fit for measurement. Two cleavage planes of about 120° are easily obtained.

Wallerhausen finds the Chladnit similar to Wollastonite and he speaks of bi- and uniaxial microscopic crystals. The density according to him is 3.069. Analysis by Wallerhausen,

Silicic acid 67.14 Alumina 1.48 Oxyd of iron 1.70 Magnesia 27.12 Ca 1.82 Soda — Water .0.67 = 99.93

If we add the remaining bases of magnesia in such a manner that the whole has the composition of Magnesian tersilicate ~~or~~ combination among minerals until now not known.

Long after him comes Stromeyer's examination of the minerals resembling Olivine and in the manner proposed by Grimmer found to contain masses of iron, but this substance is basic and

contains essentially iron oxide.

Silicic acid 61.88 Magnesia 25.83 Iron oxyd
9.12 Mn_2O_4 0.31 Chromic oxide 0.33 Loss by
ignition 0.45 = 97.92

Stromeyers acceptance of it as a trisilicate, according to Rammelsberg, is not right, for the oxygen contained in the bases and acids is as 1:2.6 according to which 1:2.5, accepting the composition that could be expressed by $2MgO \cdot SiO_2 + Mg_2O \cdot Si_3O_2$ or $3MgO \cdot SiO_2 + MgO \cdot Si_2O_2$.

It is to be regretted that about this mineral so few particulars are known. The acceptance of Wallershausen of 5 per cent of Labradorite mixed with it and allotted to the alumina appears to be ill founded.

Through the kindness of Gustav Rose and Dr. Hornes in Vienna Rammelsberg obtained enough quantity of this stone to make an examination. He observed the easy cleavage of

the crystals. The colored part of the crust was removed as well as possible as well as the yellowish brown and bluish green particles in the interior. That appears to have arisen by exposure of the iron sulphide to the air or from the oxidation of metallic iron.

In fact the particles attracted by the magnet are so few that it is necessary to seek for them. Shepard says that the stone incloses small bodies of Nickelion, even a small quantity of brown pyrites.

Rammelsberg treated first of all the finely powdered stone in warm concentrated Hydrochloric acid and boiled the undissolved portion with a solution of Carbonate of Soda.

By this means there was a residue of 90.75%. The decomposed portion consists of carbonic acid and 2.29, Iron oxyd 0.97, Manganese oxyd 0.20 Magnesia 3.51 Lime 0.58. To it must be added

0.8 of moisture and perhaps also some alkalis.

That which the acid decomposed is evidently no peculiar mixture of iron oxides or rather hydrates, and the entire mass, whose silicic acid was not-completely separated from the part-unattacked. This last was divided into two parts and expelled with carbonate of soda and Hydrofluoric acid, where upon 100 parts of the mass contained,

Silicic acid 60.86 Alumina 3.00 Oxide of iron 0.31
Magnesia 34.48, Lime 0.11 Soda 1.26 Potash
0.93 = 100.95

Reduce this result to the basis of 90.75 parts and the calculated constituent parts of the separated portion are

Silicic acid 57.52 alumina 2.72 Iron
oxide 1.25 Manganese oxide 0.20 Magnesia
34.50, Lime 0.66 Soda 1.14 Potash 0.70. Loss by

ignition ~~was~~ 0.80 = 99.79

First-of all arises the question, is this a combination or mixture of one or more minerals. He believes the latter because the alumina pointed out in the small quantity of the silicate at-hand also his researches so widely different from those in a former communication, in that one the acid amounting to nearly 70% is surprising. There is no means of mechanically separating the white mass, it shows no other separation than a greater ^{con}ference in some places. He has separated the lightest from the heaviest to find the essential elements, to be sure not with the hope of by this means to effect a separation of the mixture but only with the purpose to constitute the like or different combination of both parts.

	the lighter part	the heaviest part
Silicic acid	58.74	57.15
Alumina	6.16	2.13
Oxyd of iron & Mn.	1.82	2.71
Magnesia	29.78	36.71
Lime	1.70	<u>1.48</u>
Loss (alkalies)	<u>1.80</u>	100.15
	100.00	

Also in fact both are different and the clays and alkalies containing silica is especially contained in the light part.

Accordingly it appears to him entirely useless for one to come out now to conjecture about this combination. He believes Stromeyer's view to be a rash one.

Alais.

Fell near the villages of St Etienne de Lode and Valence. D^é du Gard. France, on March 15 1806 at 5½ P.M. Two stones one of 4 and one of 2 Kg. Density 1.94 (Biot) and 1.7025 (Rumford).

Described by Berzelius. found to contain 17% CO_2 (Thenard) analyzed by Berzelius and others. according to Berzelius on treatment with water he separates 1st. 13.28% by the magnet, dark, without luster, especially FeO , Fe_2O_3 , traces of Fe and FeS . 2nd. 11.59% soluble in water (MgSO_4 , CaSO_4 , Na_2SO_4 , K_2SO_4) traces of Ni , NH_3 , and an organic substance. The most of this compound is formed perhaps at first in the course of time by the action of the oxidizing influence of the iron sulphide upon the silicate. 3rdly. 75.13% principal part. Exposed to dry distillation it becomes pulverized.

a - 88.146% dark residue, burns to red in the air. B.B. fuses with difficulty. b. - 0.944% grayish brown sublimate. c. - 4.328% H_2CO_3 . d. - 6.582% water. The escaping SO_2 is not particularly determined.

I is Thenard's analysis, II that of the Commission of the Institute of France and III. and Berzelius

	I	II	III
SiO ₂	21.00	30.00	31.22
MgO	9.00	11.00	22.21
FeO	40.00	38.00	29.03
Mn	2.00	2.00	(MnO) 0.26
NiO	2.50	(Ni) 2.00	(FeO, Al ₂ O ₃) 0.63
Cr	1.00	2.00	(NiO) 1.38
C	1.00	2.00	
S	3.50		
Al ₂ O ₃			2.36
CaO			0.32
*			0.80
**			5.69
	<u>80.00</u>	<u>87.00</u>	<u>96.90</u>
CO ₂	<u>17.00</u>		
	97.00		

* = Oxide of iron and copper.

** = Residue upon analysis affords evidence of protoxide of iron and Magnesia, it also contains Al₂O₃, Ni & Sn

The loss consists of part of the oxygen which belongs to the iron. Literature Pages Journ de Phys. vol 62 p 440

Gieb. Ann vol 24 p 189. Thenard, Fourcroy etc do. vol 24 p 202. Berzelius. Pogg. Ann. vol 33, p 113 P. sto ch 13

The above translated from the German

Nitrogen was discovered in this meteorite by Berzelius.

CHEMICAL NATURE of METEORITES

The elements are associated in meteorites in the same manner as in the solid masses of terrestrial mineral bodies and these minerals are in part identical with the terrestrial, in part completely analogous.

Angelot has arranged in a table the elements which up to the present time have been found.

1	Oxygen	Stone	Iron	Wöhler Orifak.
2	Hydrogen	"	"	Graham Senarto
3.	Nitrogen	"	"	Berzelius Alais
4	Sulphur	"	"	Rath Pultusk
5	Phosphorus	"	"	Xiquipilco. Pugh.
6	Chlorine	+	"	Pisani Argueil
7	Carbon	"	"	Kaba Wöhler

Element-	Stone	Iron	Where found.
8 Silicon	"	+	Taylor. Okl. Lib. in
9. Kalium	"	+	Frapolli. Macomber
10 Sodium	"	+	Salt-Road by 3 miles
11 Calcium		+	Senarto. Hager
12 Lithium	"		By Engelbach - Capeland
13 Strontium	"		do do.
14 Magnesium	"	"	Von Front Nebraska
15 Aluminum	+	"	Jaborzicka Langier
16 Selenium		"	
17 Arsenic			Piddington - Shalka.
18 Chromium	+	+	Sixna. Grotthus
19 Molybdenum			
20 Silver			
21 Copper	+	+	Smith Bates Co Mo
22 Tin	+	+	Jackson Bear Creek
23 Nickel	+	+	Shepard Lion River
24 Cobalt-	+	+	Hager Haschma
25 Iron	+	+	Clark Senarto
26 Manganese	+	+	Genth Pittsburg.

stone.

Titanium + Rammelsberg's

Besides these von Stolger believed he had found beryllium in the stone of Bohumilitz but Berzelius has shown later von Stolger's error.

Each meteorite consists of a mixture either of one or more minerals. Meteorites are comparable thus to the crystalline rocks and their distinction and distribution depend upon the nature of the associated minerals.

This principle which has for a long time been employed for the crystalline rocks furnishes us a case in point where the mixed part could undoubtedly be known either by observation or examination.

We find such ones among meteorites and it is, for example, possible to determine with precision the nature of the constituents of

many Chondrites, Howardites etc.

The pure mineralogical research of Meteorites begins with the beautiful work of Gustavo Rose on the crystalline minerals which compose the Eucrite of Juvenas and to him we are indebted for a careful description of the meteorites of the Berlin Collection.

Haidinger, Reichenbach, Maskelyne and V. von Lang have by observation and microscopic research and by free use of goniometry essentially rectified and enlarged our knowledge of meteorites and will be freely quoted from.

The analyses of meteorites from the ^{former} ~~first~~ to the first quarter of the present century by Howard, Vagueelin, Saugier, Klaproth and others are still of historical interest. One studies the masses as a whole and afterwards the largest part by very imperfect methods.

Bergelius first showed by his labors upon the meteoric iron of Bohumilitz, Elbogen Pallas and the stones of Seres, Lunsko and Chantonmay, how we by analysis can arrive at a knowledge of the separate minerals.

After his in later times rank numerous researches which to be sure are not always complete nor trustworthy. Long ago Rammelsberg showed by an infallible method, with Euclite how completely the chemical analysis leads to information of a species of mineral and it has succeeded now to prove the constituency of Mesoxidites, Chondrites and Shalkite.

We are greatly indebted to Wöhler for his own labor and the work suggested by him, still to be done in this department.

Satisfactory results are obtained by the mutual mineralogical and chemical analyses of Meteorites. Maskelyne in this way in later

times met with great success and he regards the advent of this inquiry as representative.

The following subordinate division of this dissertation is taken freely from Rammelsberg, Gustav Rose, Haidinger and others and it is intended to be an exhaustive review of the present state of our mineralogical-chemical knowledge of meteorites. following Gustav Rose's classification with a modification by Rammelsberg.

Up to the present time the minerals proved to have been ascertained are;

- A Isomorphous Compound of Elements.
Nickelliferous Iron
Phosphide of iron and Nickel.
- B Sulphur compounds.
Oldhamite, or, Calcium Sulphide
Troilite, Sulphide of Iron.
Pyrrhotite, $Fe_8 S_9$

C. Oxys.

(?) Magnetic iron earth $\text{Fe}, \text{Fe}_3\text{O}_4$ Chromic iron $\text{Fe}, \text{Cr}_3\text{O}_4$ Silicic acid. (Tridymite?) SiO_2

D. Silicates

a. Normal - (members of the Augite group)
Enstatite MgSiO_3 Bronzite $(\text{Mg}, \text{Fe})\text{SiO}_3$ Augite $(\text{Mg}, \text{Ca})\text{SiO}_3$ and $(\text{Fe}, \text{Mg}, \text{Ca})\text{SiO}_3$ b. Sub-silicatesOlivine $(\text{Mg}, \text{Fe})^2\text{SiO}_4$ Anorthite $\text{CaAl}_2\text{Si}_2\text{O}_8$

The sulphur compounds and the oxides take only a subordinate part in the aggregate of meteorites which are divided in the following manner

I Meteoric iron**II** Meteoric iron and silicates

1. Meteoric iron and Olivine

2. Meteoric iron and Bronzite

} (Pallasite.)

3. Meteoric iron, Olivine and Bronzite.

III Silicates (often containing a little meteoric iron.)

1. Olivine (Chassignite)

2. Olivine and Bronzite (Shalkite)

3. Bronzite

4. Enstatite (Chladnite)

5. Enstatite and Diopside

6. Augite and Anorthite (Eucrite)

7. Olivine, Augite and Anorthite (Howardite)

I METEORIC IRON

Meteoric iron is apparently a homogeneous mass which consists essentially of iron and nickel. & Of visible admixtures many meteoric irons contain iron sulphides, in large and small and sometimes cylindrical grains.

1st a part is separated from the mass of iron so that in a hydrochloric solution the sulphuretted hydrogen can be recognized.

Our first account of the nature of meteoric iron was furnished by Howard in 1820, by means of the chemical analysis of the meteoric stone which fell at Benares in Bengal in 1798 he made the remarkable discovery that Nickelliferous iron was disseminated through it. He found 35% in it - and a somewhat similar return in other native irons, which were regarded as meteoric, as the iron of Olumpa in Brazil, Krasnojarsk (The Pallas-iron) the iron of Bohemia and Senegal

Later, Klaproth confirmed the discovery of Nickelliferous iron by the examination of the iron of Agram and Elbogen, although the quantity found in it was very slight (only 3.5 and 2.5%) and for a long time it was customary to consider the nickel compound a characteristic indication of Meteoric iron and casually iron masses found upon the surface of our earth

their meteoric origin was not accepted until then when the chemical examination of the contents proved them to be nickel, a hypothesis which authorized furthermore that never yet has a meteoric iron been ~~formed~~ found without the presence of nickel (H. Rose). Telluric native iron contains no nickel, if it does, it generally is an extraordinary curiosity, and even usually is only obtained by a process of reduction.

Later; Stromeyer found in meteoric irons some cobalt with the nickel, that even in them the nickel is wont so frequently to accompany telluric minerals and then even some copper and Saugier found in the meteoric iron of Krasnjarsk and Brahin some Chromium 0.5%, that however occurring in the meteoric stones as that, where he had formerly found it proceeded from intermixed chromic iron.

Our knowledge of the chemical properties of

meteoric iron was the most enriched through the accurate analyses of them by Berzelius, which he at first, upon the suggestion of Count Caspar Sternberg, had applied to the iron of Bohumilitz in Bohemia and then by his great general work upon meteorites which was occasioned in 1833 by Baron von Reichenbach's transmitting the meteoric stone which fell at Blansko in Moravia the same year, the iron of Krasnojarsk, and that of Elbogen. He separated from them a soluble and insoluble part by treating the meteoric iron with dilute Nitric acid and in this way found in the iron of Bohumilitz (a) Krasnojarsk (b) and Elbogen (c) the result following on the next page. The residue in the dilute Nitric acid consists of metallic grains and scales which sink to the bottom, and from a finely divided black carbon like mass, the impurities can be separated by washing.

	<u>a</u>	<u>b</u>	<u>c</u>
Iron	93.775	88.042	88.231
Nickel	3.812	10.732	7.517
Cobalt-	0.213	0.455	0.762
Magnesium	—	0.050	0.279
Manganese	—	0.132	trace
Zinc & Copper	—	0.066	trace
Carbon	—	0.043	trace
Sulphur	—	trace	trace
Insoluble	<u>2.200</u>	<u>0.480</u>	<u>2.211</u>
	100.000	100.000	100.000

The first was a remarkably white phosphide and consists of

Iron	65.987	48.67	68.11
Nickel	15.008	18.33	17.72
Magnesium	—	9.66	
Phosphorus	14.023	18.47	14.17
Silica	2.037	—	—
Carbon	<u>1.422</u>	<u>—</u>	<u>—</u>
	98.477	95.13	100.00

The latter, which upon heating fumes and then subsides, was examined quantitatively only with the Pallas-iron and consists of

Iron	Nickel	Magnesium	Sn, & Cu	C	total
57.18	34.00	4.52	3.75	0.55	= 100.00

a trace of phosphorus, ^{which} Berzelius found. The blebs must be ascribed to the enclosed parts of the phosphide. In the residue from the Bohumilitz iron some silica and chromic iron were also found. This finer part of the residue is essentially, differently composed from that of the heavier.

Berzelius was thus the discoverer of six new substances in meteoric iron. Phosphorus, Tin, Manganese, Magnesium, silica and Carbon of which the phosphorus is quite remarkable, such phosphoric metal there, as is accordingly contained in meteoric iron is not known among the terrestrial minerals.

After Berzelius there were now made more analyses of other meteoric irons and by other chemists according to that or similar methods but the results yielded were not entirely similar. In all, one was insoluble in dilute acids, chiefly obtained from the residue consisting of phosphide of nickel and iron, it was like that obtained by Berzelius always, only in very small and changeable quantities, and besides the proportion of phosphorus to iron and nickel so different or variable, that a common formula for the chemical composition of this salt can ^{not} be made. This insoluble part Haedinger had when occasion offered, that of Patera performed an analysis of the meteoric iron of arva, in which the same is contained in ratio of ~~to~~ greater quantities, he has given to this the name of Schreibersite, to honor the former director of the Imperial Mineral Cabinets in Vienna, who has merited this by the additions to meteoric

science made by him through the publication of his contributions about the history and knowledge of meteoric stone and iron masses.

But very much earlier than Berzelius^{showed} by his chemical examination, the heterogeneous nature of meteoric irons, Widmannstätten in Vienna had proved in another way. He showed, namely before 1808, that when the ground and polished surface on a meteoric iron is etched with a weak acid, certain figures appear, which have since been called Widmannstätten figures. The surface, which before the etching appears quite uniform, or only by the highest polish and after moisture faint indications of figures appear, it now affords or appears to be covered with faint, lusterless, parallel bands under one another, which traverse it in different directions, intersecting by very differ-

oblique angles, of thin, projecting, enclosed by metallic shining edges and a dark dead field, which all showed a very complicated structure of the meteoric iron. Particularly beautiful were some of the figures upon the large pieces as that cut off from the Elbogen iron in 1812 and brought to Vienna.

There, the faint surrounded edges or strips, which were but little if at all attacked by the dilute acid, by the etching projected somewhat beyond the mass, then Widmannstätten was struck with the idea that the etched iron surface could be used as an engraved plate in the letter-press, which was a complete success. He could by this furnish illustrations completely true to nature as it was impossible for art to accomplish. V. Schreiber described in his famous work the individual parts of meteoric irons, the bands, the enclosing borders and

middle ground and gave also an impression of the etched surface of the great Elbogen mass in the Vienna mineral cabinets; the deep places in it are white, and only the high places, the borders are black, in part also the middle ground which again often appears banded.

Whilst all meteorites do not all yield Widmannstätten figures and especially is this the case in the Brauner iron which fell in the year 1847, by which Haidinger made the remarkable discovery, that it is cleavable in its entire mass according to the three rectangular planes among one another parallel to the surface of the hexoctahedra. It fell in two masses, both of which were obtained by the Prelate of the ~~xxx~~ cloister of Braunauer Sten Rotter, its largest part weighing 42 pfund 6 Loth or 75.96 grammes or

0.7596 kilos. was cut up and a single piece sent around to the different museums as a present. In the piece, which the Imperial Cabinet of Vienna obtained, Haidinger made the above observations.

It was as the rest of the part cut through and the further separation brought forth by breaking, so that its plane of natural fracture was visible.

Then the cleavage plane upon the entire fracture surface and consequently it is probable that it extends through the entire piece in the same direction, so that the entire piece and also the entire mass, from which it is cut, a piece of one individual, a crystal whose outer form could not be more perceptible. Because in its passage through the air it burst and a single piece on its surface is fused, whose inner structure in that

piece cannot be obtained. Haidinger ground etched the piece he had, and produced no Widmannstättenian figures, but there were visible other straight and among one another parallel lines after increasing courses, which afterwards were ~~de~~ carefully described and indicated in regard to their direction by Neumann.

Baron von Reichenbach has separated from Meteoric irons which yield Widmannstättenian figures, four components which by etching of the polished surface were visible and which he designated by the name of Beam iron or Kamacite, hoop iron or Ganite, ~~Plessite~~ or Plessite and Iron glance or Samprite. The beam iron forms upon the etched surface strips parallel to one another which intersect in oblique angles (of 30° , 60° and 120°) and thus occupy the great-

est-space, by etching it is gray and without luster and shows itself covered now with parallel lines like the Braunau iron, which Reichenbach called hatched lines ^{and} maintained to be indications of cleavage surfaces. in many cases it even appears granular, especially in the iron of Ruffs mountain.

The hoop iron enclosed the strips of beam iron and covered them on both sides in leaves thin as paper, it is colored a faint reddish ^{yellow} color by the dilute acid, always slightly or not at all attacked and projects from it upon the etched surface above the beam iron edgewise.

The ~~Pillman~~ fills up three or four sides of the field which was enclosed by the beam iron; it was attacked by the etching as the beam iron and often by it, a still darker gray color, as this. It is ^{not} present in many varieties as in the iron of Ruffs mountain and frequently it not only fills out the

field but often still contains a great quantity of leaves which in consecutive parallel directions converge to one another and on four sided fields usually two parallel sides,; often however at the part which both other parallels lie, in which latter case the laminae are confined together in a diagonal of the square. Reichenbach called these the middle ground filling out leaves of the hoop iron comb.

The iron glance lies in the single long grains and strips in the middle of the beam iron.

It is not attacked by dilute acids and retains the full glitter and the light, steel gray almost tin white color which it obtained by the polish of the surface. It is not found in all meteoric irons, quite distinguished in that of Senarto and Arva.

That meteoric iron which contains interpenetrated crystals of silicates (Olivine Bronzite) the iron of pallasite, is entirely, or at least its chief mass is a crystal (Steinbach, Littersgrün or it is a granular aggregate of augmented crystals (Pallas mass, Breithorn, Alacama) and accordingly the cleaving is different. This variable structure which meteoric iron presents is repeated in the scattered growth of silicates, may be its quantity and parts are greater, as in the mesosiderites or smaller as in the Chondrites.

According to Reichenbach the hoop iron is (Density 7.428) heavier than the whole (7.266) but the question whether these as such different kinds are also chemically different is still unsettled. because they cannot be mechanically settled. To be sure Reichenbach had in the hoop or malle-

ble iron (a) and in the entire mass after
 two analyses ^{(b) + (c)} of the Meteoric iron of Cosby
 Creek found a b c

Iron	85.714	90.125	89.324
Nickel	13.215		10.123
Cobalt-	0.550	9.786	0.422
Sulphur	0.226	trace	trace
Phosphorus	<u>0.295</u>	<u>0.089</u>	<u>0.131</u>
	100.	100.	100.

Reichenbach does not believe these figures
 furnish a complete explanation of the
 chemical properties of the malleable
 iron and Rammelsberg agrees with him
 The most varieties of meteoric irons contain
 still another compound, fine needle
 shaped crystals or Needles as Reichenbach
 briefly calls them.

Wöhler first made the observation, that most
 meteoric irons are passive, that is, they do not
 reduce a solution of copper sulphate.

Only by contact with ordinary iron in a state of fluidity or upon the addition of acid is copper reduced. This property is not merely superficial it belongs to the mass of the iron. To the active irons belong: Senarto, Chester County; Rasgata; Mexico (not Toluca), Senegal. Many are brought forth after a long time of reduction, Agram, Arva, Alacama, Burlington. According to Wöhler this behavior with the nickeliferous iron and which by the structure conditional property stands in no relation to the formation of the Widmanstätten figures.

Leunier has discovered that passive iron, such as that of Charcas, also the nitrate of copper, Silver and Mercury do not reduce. On the contrary it decomposes the chloride of Gold, Platinum, and Mercury and in the heat copper sulphate also.

Plunged into Nitric acid of a density equal to 1.34, the meteoric iron of Charcas is like steel, equally passive, if the surface is freed from oxidized particles

Münier has attempted to separate the individual combinations or alloys from the meteoric iron. He fuses the fine powder with caustic potash, by this means the iron sulphide the schreibersite or phosphates of iron and nickel, and the silica are removed, treated the mass with water, washed the iron with fuming Nitric acid (which does not attack it; but it removes the graphite) then treat with water, alcohol and ether. The powder is now heated until a part of the body is colored blue whereupon this is mechanically separated. He calls the blue part Kamacite and the yellow part Taenite. The meteoric iron of Cuille and Charcas consists according to him, only of

these two. The iron of Oldham Ky. gives a somewhat yellow Taenite, purplish red Kamacite and blue Plessite (formerly he called the blue body, Kamacite).

Taenite. Its density is 7.38 (7.428 Reichenbach) It consists (from the meteorite of Caille) of 85 iron and 14 Nickel

If a thin plate of this meteorite is treated for a long time with dilute acid (Nitric), the Taenite is left behind as a fine network and this gives 85% of iron. Reichenbach has, as already cited, found 13.765% of Nickel and Cobalt: according to this the Taenite was Ni Fe_6

Kamacite This part of the meteorite of Caille, whose density = 7.652 contains 91.9 Iron. 7.0

Nickel or it is about Ni Fe_{14} De Laj. Suynes finds 87.63 Fe Ni 17.37 or Fe Ni 5 and Rivot finds 92.3 Fe and 6.2 Ni or Fe Ni 15 and in another analysis 92.7 Fe and 5.6 Ni or Fe Ni 16

Plessite. What Meunier so called is perhaps not exactly the Plessite of Reichenbach. He makes its density 7.85. Ni Fe_{10} Analysis is not quoted it oxidizes less easy than Kamacite, easier than Taenite. He found considerable of it in the iron of Jewell Hill N.C. which according to Smith it contains 91.12 Fe, 7.82 Ni, 0.43 Co, 0.08 P, trace Cu. and in that of Aldham Co Ky in which according to Smith there is 7.81 Ni and 0.25 Co.

The analyses up to the present time give with more ^{less} accuracy the matter contained in the total mass. By solution in Hydrochloric acid there is evolved some times an offensive odor of hydro-carbons (Bohumilitz according to Berzelius) which indicates the presence of combined carbon.

Iron and nickel are the chief constituents the latter is generally accompanied by a little

cobalt-. The nickel and cobalt varies 4 and 20% that is for 1 atom of nickel there is twenty five to seven of Fe in the isomorphous union of both. An average of numerous repeated analyses containing 10% Ni correspond to Ni Fe_9 or Ni Fe_{10} . By way of exception the chondrites (the common or oligoclase meteorites) bear up in accordance with the statement of a still higher quantity of nickel.

Tula	27.86	}	Ni Fe_3
Buechhof	26.57		
Honolulu	37.00		Ni Fe_2

In the Tula iron it is finely divided in the silicate, the iron of the principal mass contains only 10.24% Nickel according to Ramsdellberg. But the largest amount of nickel is contained in the meteorite of Aletchka Co Miss. analyzed by Taylor, 59.69%, this is nearly $\text{Fe}_2 \text{Ni}_3$

211

Besides these constituents many analyses give a very small quantity of Tin or Copper. The presence of the silicate is natural, Berzelius however maintains the presence of magnesia for them. Sulphur is brought into the slag in the form of Fe S . Phosphorus is proved to exist in many ways, we do not know whether this element as it is contained is of a dual nature, for it can just as well be, that the principal mass being easily soluble in acid contains phosphorus, that that which remains is not without effect upon the difficultly soluble part and the remainder, forming the phosphides. R. von Reichenbach treated the meteoric iron with very dilute hydrochloric acid at the ordinary temperature. He found that the insoluble part consisted of a dark gray body and of light-leaves or plates, the latter he claimed

to be malleable iron. At first, it dissolves on heating, but the grains are smaller and are altered to a sandy, fine black powder in which the latter are metallic particles.

From this kind, the Meteoric iron of Arva and of Bushy Creek gave 10% of residue which consists of iron, nickel, and about 1% of Phosphorus. If it is heated with stronger acid it loses about 2%, also 45-uns of it is dissolved, and there the black particles of the slimy pulverulent residue contain from 4 to 5% of phosphorus, then the acid does not affect the solution of these constituents. It is by this means the conclusion is justified that the phosphorus does not belong to the entire mass but to an insoluble compound contained in it.

The 2% of residue is soluble with great difficulty in Hydrochloric acid, but is easily

210
so in nitric acid or aqua Regia.

To Berzelius we are indebted for the first investigation of residues which are left behind in solutions of meteoric iron and which vary in amount from the fraction of a percent up to more than one percent.

Berzelius found the residue (Met-iron of Bohumilitz - Pallas iron), ^{to be} consisting of an imponderable black powder and a heavy, metallic, lustrous crystalline portion.

Rammelsberg has observed the same difference; Bergmann and others have separated a black powder from the metallic particles.

The analysis of this residue yields iron, nickel, and phosphorus as chief constituents and the crystalline, often plainly crystallized, part of it, has shown this to be schreibersite, is a well defined salt or mineral, but the crust is proved to be

of varying proportions; that it either is an isomorphous mixture or is intermingled with others. Table I gives a clear review of the analyses of them.

Meunier produced the schreibersite by digesting the filings in a solution of copper sulphate treating the residue with cold fuming nitric acid and remove it with a magnet. By means of hydrochloric acid he removed the adhering sulphide of iron. He treated the meteoric iron of Toluca in this way (Table II) see page 381

Silicates. In ^{a single} meteoric iron small quantities of silicates are found. In the mass of iron of Tazewell and of Tucson, the Olivine appears to be so represented. In the sulphides of the meteorite of Baille and of Bharau it is similarly found, that is, ~~the~~ in the insoluble part.

Meunier, from whom this statement is derived has taken precedence over everybody in minute analysis

It appears to be proved that iron and stone meteorites are not formed in sharply defined groups.

Carbon, or Graphite; It has been mentioned, that in many meteorites, a small quantity of combined Carbon occurs, because the decomposition of the gases evolved was accompanied by such an odorous compound as is obtained from pig iron. It is concealed in the meteorite of Bohumilitz, according to Bezelius, that of Misteca according to Bergmann that of Seelassen according to Rammelsberg Besides, however, the presence of graphite in several ways is stated (Awa, Coshy, Bohumilitz, Lenanto, Sevier Co, Toluca) Graphite is found in small rounded grains, in the interior constituting portions from ~~dense~~ compact accumulated little heaps up to the size of a hazel nut or walnut

sometimes however as Haidinger has observed of the iron of Arua in Pseudomorphs. Haidinger believes he has recognized in it the form of ^athe combination of the Hexahedron and the pentagonal dodecahedron and deduces this from it, that the pseudomorphs were originally from iron sulphide, a view which G. Rose cannot agree to, and there ~~was~~ ^{was} no certainty up to his time that iron pyrites had been found in meteorites and the pseudomorph even which Haidinger had the kindness to send to Rose, seemed to him to have more the form of a hexahedron with sharp ^{rather than inclined} ~~and~~ blunted edges. It could be asked now, from what then did the pseudomorphs originate. The next rational assumption is, that these have once been diamonds; if however this assumption is confirmed by the form

of the pseudomorph and the possibility of formation, we then find a difficulty to surmount, that up to the present time the diamond has not yet been found in meteoric iron.

If, according to Reichenbach, the graphite is in the form of large grains, even lumps, in the iron of Cosby, whose density is 3.564 then this proves that its mass is not pure.

An accurate research upon meteoric graphite is much to be desired (Meunier has discovered in the graphite of Caille 2.4% and in that of Charcas 0.9% of iron)

Hydrogen in Meteoric iron

Graham thinks that the ~~iron~~ gases which iron holds occluded are borrowed from the atmosphere in which the metallic mass last found itself in a state of ignition.

He chose the iron of Senarto for his investigations. This well known iron being free

from any stony admixture and remarkably
 pure and malleable. From a strip of the
 Senarto iron 50 m.m by 13 and 10 m.m, the
 made his trial, it weighed 45.2 grammes and
 had the bulk of 5.78 Cu. c.m. The strip was well
 washed by hot solution of polish, and then
 repeatedly by hot distilled water and dried;
 such treatment of iron it had been found
 conduces in no way to the evolution of hy-
 drogen gas when the metal is subsequently
 heated. The Senarto iron was enclosed in
 a new porcelain tube and the latter being
 attached to a Sprengel aspirator, a good
 vacuum was obtained in the cold. The
 tube being placed in a rough combustion
 furnace, was heated to redness by ignited
 charcoal. Gas came off rather freely, namely

In 35 minutes	5.38 c.c.m
---------------	------------

In 100 "	9.52 "
----------	--------

In 20 "	1.63 "
---------	--------

In 2 hours 35 minutes =	16.53 "
-------------------------	---------

The first-portion of gas collected had a slight odor, but much less than that of the natural gases occluded by ordinary malleable iron. The gas burned like hydrogen, it did not contain a trace of carbonic acid, nor any hydrocarbon vapor absorbable by fuming sulphuric acid. The second portion of gas collected consisting of 9.52 cub centims., gave by analysis,

Hydrogen	8.26 cub. centims	...	85.68
Carbonic oxide	0.43	" "	4.46
Nitrogen	<u>0.95</u>	" "	<u>9.86</u>
	9.64		100.00.

The Senarto iron, appears therefore to yield 2.85 times its volume of gas, of which 86% nearly, is hydrogen. The proportion of carbonic acid is so low as 4 1/2 %. It has compared these results with those obtained by treating horse nails in the same way and from this

223
comparison he derives the conclusion that the predominance of carbonic oxide in the occluded gases of a meteoric iron is sufficient to attest its telluric origin.

It has been found difficult, in trial, to impregnate malleable iron with more than an equal volume of hydrogen under the pressure of our atmosphere. Now the meteoric iron gave up about three times that amount without being fully exhausted. The inference is that the meteorite has been extruded from a dense atmosphere of hydrogen gas, for which we must look beyond the light-cometary matter floating about within the limits of the solar system.

J. W. Mallet made a similar examination of an iron from Augusta Co Virginia, but agree rather with Graham's experiment upon horse nails than with the meteoric iron.

Sulphide of Iron (Troilite)

It occurs very abundantly and no doubt in a very finely divided state, in grains and large cylindrical masses, it is easily soluble and has a brown or yellow color at one time and another sulphur pyrites has been taken for magnetic pyrites, it was later shown by Rammsberg to be a sulphide. Fe. S.

Can its (from the meteorites of Seelager, of Sevier Co) composition be?

$$\begin{array}{r r r r r} 1 \text{ At- Iron} & = & 56 & = & 63.63 & = & 7 \\ 1 \text{ " Sulphur} & & 32 & = & 36.37 & = & 4 \\ & & 88 & & 100 & & 11 \end{array}$$

Or is it ^{mixed} with finely divided nickeliferous iron (Toluca and Knoxville according to Taylor and Smith) The density of Troilite is found to be from 4.75 - 4.787 - 4.817; the smallest number is certainly nearest the truth for every mixture of iron increases the density and the

artificial Fe.S weighs nearer 4.75

If magnetic iron pyrites occurs in the silicates of meteorites (Eucrite), then it becomes possible also in meteorites. By this it is to be observed that a mixture of 92-93% of it and of 8-7% of Nickelliferous iron must yield a combination of the sulphide (Troilite), even the iron containing nickel is not separated for it yields magnetic iron containing nickel. Only the formation of hydrogen in a sulphuric acid solution could solve the question.

(The density of pyrrhotite on the average is 4.6)

Münier separates the sulphide from the nickelliferous iron by this means, then digests the powder with a concentrated solution of copper sulphate, by cold fuming nitric acid, which does not attack the sulphide, is the metallic copper removed, whilst some graphite and schreibersite remain in it. By the attrac

of the magnet - the pyrrhotine and schreibersite are removed under water, they are separated by washing with water. Instead of copper sulphate he has used chloride of mercury avoids the separation of mercury and removes the chlorine by weak chlorine water.

Neunier has found further that artificially produced sulphides (Fe.S) reduce copper salts whilst magnetic pyrites do not. According to his observations, the sulphides of meteoric iron behave in this respect - like magnetic pyrites. This statement, according to Rammelsberg's experience is not tenable, HgCl_2 also decomposes Fe.S) He found in the one from the meteoric iron of Toluca density 4.8 (a) and in that of Chaupas density 4.78 (b)

a	Iron	Nickel	Sulphur	Total
a	59.01	0.14	40.03	= 99.18
b	56.29	3.10	39.21	= 98.60

Rammelsberg does not contradict Meuser's statements but observes that the density of the substance is incompatible with the views advanced.

Table I gives the composition of the meteoric irons as well as they are known, as also that of Pallasite, Mesosiderite & chondrite examinations in alphabetical order.

Table gives the composition of residues from hydrochloric acid solutions of meteoric iron

II.

Meteoric Iron and Silicates.

The majority of meteorites contain such composition, but its character is determined by the nature of the silicate and the kind of formation

The meteoric iron is capable of examination in various respects.

Meteoric iron either forms a coherent mass, a principal body, in which the crystalline silicate is of a porphyritic structure or the reverse, the silicate or a combination of silicates form the chief aggregate in which the meteoric iron is dispersed in large or small particles. Its accessory components are iron sulphide and chrome iron.

The first kind forms very peculiar masses, which by the predominance of metallic iron is ranked next to meteoric iron. Its descent up to the present time has not been observed. Its type is the iron of Pallas, the first described siderian mass, according to which the entire series is distinguished as Pallassite.

So far, experience shows that only one silicate is formed in meteoric iron, and this is either Olivine (Unisilicate of Magnesia and

and iron) or Augite (Si-silicate of magnesia, or of magnesia and iron) From this arises two subdivisions Olivine Pallasite and Augite-Pallasite. G Rose had in 1864 called the combination of meteoric iron and Olivine, Pallasite, at that time the presence of Augite had not been found.

I. Meteoric Iron and Olivine

(Olivine = Pallasite.)

I Pallas-iron. It was found by Maderew in 1749 upon a hill between two tributaries of the Yenesee the Ubi and Sisim. In 1771 it was brought by Pallas to Krasnoyarsk and later taken to St-Petersburg. Its description by Pallas occasioned Ohladni's famous work, which maintained the true nature of meteorites, first of all, and strikingly opposed to the views of the savants of his time.

G Rose has described the Olivine

Kolschatow later furnished our knowledge of its crystalline form. Berzelius analyzed the iron. Whilst the Olivine by him, Wernstedt Stromeyer and still later by H. von Seuchtenberg has been studied.

II. Brahin. Government of Russia. Like the Dallas iron is of a high grade. There is extant only the older, insufficient details by Saugier Rammelsberg has studied them lately.

III. Alacama. S. A. Of similar quality, the crystals of Olivine are still larger. The iron has been superficially studied by Turner. Whether the analyses by Field and Frapolli as of Danour Table I upon the same iron are reliable is doubtful. The Olivine was analyzed by Schmidt.

The two last-irons contain a little chrome iron, all three a very small quantity of pyrites.

About the structure of ~~the~~ iron, see meteoric iron.

On page 128 of this work a description of this famous iron is given.

see page

of this work

	Iron	Nickel	Cobalt-	Cu, Sn	Mg	Mn
Pallas mass	88.042	10.732	0.455	0.066	0.05	0.132

(Berzelius)	Carbon	Sulphur	Insoluble total			
	0.043	trace	0.480 = 100.00			

Brachin	Nickel & Cobalt-	
Rammelsberg	11.04	
Atacama	11	1
Turner		

Composition of Aluine

Pallas - iron

	Berzelius	Walmstedt	Stromeyer	Leuckh. Rg.	Schmied	Brachin Atacama
Silicic Acid	40.86	40.83	38.48	40.24	37.58	36.92
Alumina	—	—	0.18	0.06	—	—
Stannic acid	0.18	—	—	0.08	—	—
Magnesia	47.35	47.74	48.42	47.41	43.32	43.16
Protox of iron	11.72	11.53	11.19	11.80	18.85	15.49
Protox manganese	0.43	0.29	0.34	0.29		1.81
	<u>100.53</u>	<u>100.39</u>	<u>98.61</u>	<u>99.88</u>	<u>99.75</u>	<u>97.38</u>
Density			3.34	3.339		

According to this the Olivine of the Pallas iron contains 1 At Iron (Mn) to 8 at Mg, that of Brahin and Atacama however are both in the ratio of 1 : 4.

Pallas Olivine	Brahin and Atacama-Olivine
$\text{Fe}^2 \text{SiO}_4 ; 8 \text{Mg}^2 \text{SiO}_4$	$\text{Fe}_2 \text{SiO}_4 , 4 \text{Mg}_2 \text{SiO}_4$
9 Si = 252 = SiO_2 46.79	5 Si = 140 = SiO_2 39.27
16 Mg = 384 MgO 48.34	8 Mg = 192 MgO 41.88
2 Fe = 112 FeO 10.87	2 Fe = 112 FeO 18.85
36 O = 576	20 O = 320
1324	764
100.	100.

In composition both are alike many terrestrial Olivines. Berzelius did not find Nickel whilst according to Stromeyer it occurs in terrestrial Olivines.

Lumler and Smith have found very slight quantities of Arsenic in the Olivine of Pallas, and of Atacama.

2. Meteoric Ironnd Bronzite (Bronzite = Pallasite)

The former very similar and among entirely homogeneous masses are found not far from one another in the Erzgebirge. They appear to proceed from one and the same fall (in the 16th century).

- I Steinbach between John-George town and Eibensack found in the preceding century
- II Rittersgrün at Schwarzenberg, found in 1847 but ^{first} made known by Breithaupt in 1861
- III Breitenbach, Elbogen circle three or four hours walk from John-George town, discovered in 1861.

The iron predominates here still more, larger pieces consisting of one kind. According to Kube the mass of Rittersgrün contains 9.63 Ni, 0.58 Co & 1.37% P vide Table I. page 368

The silicate was for a long time regarded as Olivine. Even G. Rose's goniometry of the always imperfectly formed crystals appear to corroborate this view. But Von Lang has by a distinguished work proved that the silicate of Breitenbach possesses the character of Augite and indeed the biaxial form which Des Cloizeaux had already established from optical reasons for the parts containing magnesium and iron. It is, Enstatite = $Mg SiO_3$.

Bronzite
and Hypersthene } $(Mg, Fe.) SiO_3$ the latter
frequently combined with R_2O_3

The augite of the Pallas iron cited, is Bronzite which, too, was described by Rath to be in similar smooth large area crystals as in terrestrial minerals, by Lang and Rammelsberg recognized as such.

Maskelyne has briefly demonstrated the nature

of Bronzite by an analysis of the Breitenbach Silicates. But in 1824 Stromeyer examined the silicates of Sternbach, the results did not correspond to the hypotheses that it was olivine, the great degree of acidity would not sanction this. Although the analyses of modern investigators do not correspond, it can still however be shown to be Bronzite, (a) Maskelyne & (b) Stromeyer.

	SiO ₂	MgO	FeO	MnO	Cr ₂ O ₃	Loss	total
a	56.10	30.21	13.58	—	—	—	= 99.89
b	61.88	25.83	9.12	0.31	0.33	0.45	= 97.92

Density (a) 3.23 Density (b) 3.276

The corresponding like proportions of Mg & Fe, also the similar densities, speak for the substance and it can be accepted from Stromeyer's analysis. Magnesia and an undecomposed substance still remain behind in the silicic acid, which correspond to well known experience.

This Bronzite contains 1 atom of iron to 4 of

Mg. directly as the Olivine of Bahia and Atacama. It is also an isomorphous combination of Bi-silicates.

$$5 \text{ Si} \quad 140 = \text{SiO}_2 \quad 56.39$$

$$4 \text{ Mg} \quad 96 \quad \text{MgO} \quad 30.08$$

$$\text{Fe} \quad 56 \quad \text{FeO} \quad 13.53$$

$$150 \quad \frac{240}{532} \quad 100.00$$

According to Maskelyne then there is found besides, in the Pallasite of Breitenbach a not inconsiderable quantity of free silicic acid, in almost-microscopical crystals. They should have two optic axes and a density of 2.18-2.24, then it could not be conditionally accepted as Tridymite as Maskelyne appears to assume.

The pure mineral appears in the place of Bronzite and also the Bisilicate of Magnesia Mg SiO_3 the enstatite.

In a meteoric iron of the Sierra de Iruya near Santiago in Chile there is found according to Meunier very small colorless crystals in which Des Cloiseaux distinguished the presence of prisms of augite with both hexagonal faces. B. B. infusible and not attacked by acids.

Ebelmen has as is known artificially produced this silicate with the same surfaces and a density of 3.134

3. Meteoric iron, Olivine & Bronzite.

The method of association is a dual one, the iron forms as in the Pallasite, a coherent mass, in whose interstices the silicates, or the meteoric iron is in the body of the silicate. Accessory adjuncts are iron sulphides and chromic iron. To the first belongs the meteorite of Lodran. to the second belongs the mesosiderite and Chondrite.

a. Meteorite of Lodran.

Fell on the 1st of October 1868 at Lodran (Multan) in Hindostan, lately studied by Lang and Tschermak. An unconsolidated granular structure consisting of Nickelliferous iron, pale green on the surface, bluish Olivine, ~~par~~^{ax}aceous bronzite, pyrrhotine, and chromic iron. The metallic iron forms a coherent mass, a fine network and shows impressions of Olivine crystals. The Olivine is crystallized in the usual form.

V. Von Lang found $p^2 : p^2 = 130^\circ 11'$

$p^2 : b = 114^\circ 58'$ $p : b = 133^\circ 30'$

$\frac{3}{2}p : b = 144^\circ 30'$ $g : b = 139^\circ 0'$

Its density is 3.307

The bronzite shows only surfaces of the horizontal bands and no doubt - $p : a = 134^\circ 4'$

$p : b = 135^\circ 54'$ $\frac{3}{2}p : a = 108^\circ 4'$ cleavable according to a and b. Optically like the bronzite

of Breitenbach. density 3.313

Meteoric iron ¹⁾	Olivine ²⁾	Bronzite
Iron 86.36	Silicic Acid 41.09	55.35
Nickel 12.93	FeO 12.64	12.13
<u>99.29</u>	MgO 46.58	32.85
	CaO —	0.58
	Al ₂ O ₃ —	0.60
	<u>100.31</u>	

The Olivine is approximately $\text{Fe}_2\text{SiO}_4, 7\text{Mg}_2\text{SiO}_4$
calculated to

SiO ₂	FeO	MgO	
40.54	12.16	47.30	= 100.00

The Bronzite is $\text{FeSiO}_3, 5\text{MgSiO}_3$ calculated
to

SiO ₂	FeO	MgO	
56.96	11.39	31.65	= 100.00

The experimental trial proved that a little Olivine
was adhering to it. Tschermak believes, since
and Alumina proceed from the formation of
anorthite, its atomic proportions do not indicate
this but the analysis generally does not on

amount of the excess allow of an exact estimation

The chromic iron was in black grains and crystals - Octahedra, rhombohedra, leucite

$a : a : \frac{1}{3}a$ — of brown powder, was, according to the constituents found in the silicate of the Olivine composed of 24.6 Cr_2O_3 54.5 Fe_2O_3 and 20.9 MgO also

$\text{Mg Cr}_3\text{O}_4$, 2 $\text{Mg Fe}_3\text{O}_4$

The magnetic pyrites form stony grains, & left in the hydrochloric acid and gives about 60% of iron. A trial of the meteorite gave

<u>Ni, Fe</u>	<u>Olivine</u>	<u>Bronzite</u>	<u>Chromic iron</u>	<u>pyrrhotine</u>
32.5	28.9	31.2	7.4	= 100.00

b. Meso-siderite

Dr Rose has pointed out such a granular compound of meteoric iron, Olivine and Augite and places the mass of the Sierra de Chaco and of Hainholz in here, whose time of fall is unknown

According to Rose, mesosiderite is a granular admixture of meteoric iron, Olivine and Augite.

I Hainholz at Paderborn a ^{heavy} ~~hard~~ mass 33⁰ pfund or 59.4 grammes. found by Mühlenspfordt in 1856 which outwardly and up to a certain depth is altered by oxidation

The aggregate consists of large crystalline particles of lighter Olivine and darker augite. the meteoric iron occurs in it in small and large grains and are separated best by grinding.

Rammelsberg has briefly examined the three component parts of this meteorite and found

Meteoric iron	Olivine = a					Augite = b		
	SiO ₂	FeO	MgO	CaO	Al ₂ O ₃			
Iron Nickel	a.; 35.77	22.91	41.32	—	—	—	—	=100.00
	93.84	6.16				b.; 53.05	15.63	25.40 2.73 3.19 =100.00

The meteoric iron resembles in its composition the ~~iron~~ chondrite of Sere, Blansko, Meso-Madaras etc., as the meteorite of Schwitz. See-

(1) 30 Loth = 1 pfund. 1 Loth = 0.06 grammes.

larger, Braunau, Arva, Senarto, Caille etc. Both silicates contain 1 atom of iron to 3 wt-of Mg. The augite is bronzite containing alumina

Ol: 3 8.46 23.08 38.46-100. Br: 54.13 16.24 27.06 2.57=100.00

We will see, that this combination repeats itself in chondrite (for example Iowa.) The relative quantity of the three compounds may vary in a single place. The experimental trial by Rammelsberg furnished.

	Meteoric iron	Olivine	Bronzite	Chromic iron
1.	14.48	56.45	28.49	0.58 = 100.00
2.	12.70	62.78	24.00	0.52 = 100.00

The olivine also predominates, it amounts to 2-2 1/2 times as much as the bronzite

Rammelsberg did not find iron ferrites.

Whether the bronzite containing lime intimates a combination with ~~the~~ ~~def~~ diopside, is diffi-

cult-to say. In Olivine rock both occur and also Enstatite and Diopside are found in other meteorites (Busti)

II *Seria de Chaco, Uacama*. The mass is very similar to that of Hainholz. It originally weighed 28.87 Lott or 1.7322 grammes bounded by natural faces and fracture. Presented by Prof Dorneyko in St Yago in Chili. A piece was cut from it; the whole now contained a large piece of 23.9 Lott or 1.434 grammes and a small one of 1.4 Lott or .084 grammes. On the fracture it appears granular and generally greenish black and without lustre. There is recognizable only one large grain of reddish yellow Olivine and small dark green ones of Augite. Above all the finely diffused iron is almost imperceptible. Complete but distinct the mixed parts appear upon the ground and polished surface; the iron appears now equally by its steel gray color.

and its bright metallic lustre, and one can now see in what quantity it is present. It is ^{contained} in fine portions mixed throughout with small portions of the silicate which throughout with irregular, angular and indented surfaces, caught into one another and between ~~the~~ that the Troilite throughout, but in still finer state of division and recognizable by its pinch-back brown color. Between them now appears large isolated grains of nickeliferous iron, Olivine and Augite.

The Olivine is of greenish yellow to reddish yellow and brown and sometimes of considerable dimensions. Upon the outer surface was found a grain $\frac{3}{4}$ Zoll or ~~2.539~~ 7.619762 ~~inches~~ centimeters in diameter. It is divided in fissures and does not take generally as good a polish as the augite perhaps because it was already decomposed. It does not fuse nor change before the blow-pipe.

and is therefore like the ordinary olivine appearing in meteorites not abundant in iron. The Augite is olive green, upon the ground and polished surface quite dark and shining in very thin splinters however it is transparent with greenish white light, it is plainly cleavable according to the surface of the vertical prism and its cross and horizontal section and so completely, that the cleavage plane can be quite accurately measured with the reflection goniometer. Before the blowpipe this augite is only fusible in thin splinters on the outer edges to a dark glass with salt of phosphorus it forms, after separation of the silicic acid, a glass, that while hot is greenish white that becomes extinguished on cooling. Troilite is not admixed in large grains.

Domeyko has examined the nickeliferous iron of the mass.

On the other hand Joy contributed the analysis of a meteorite which nominally was found in the Punacera, a pass of the Cordilleras, Province of Alacama, Chili and according to Smith's statement is identical with that of the Sierra de Chaco. Moreover Doneyko gave the analysis of such a one from the neighborhood of Copper quarry, of Taltal, Alacama. Unfortunately both analyses are unsatisfactory. Joy has not determined the nickelliferous iron directly, as it appears. He has to be sure decomposed the silica by acid, but not the silica acid belonging to the olivine, finally he declares that the decomposed silicates contain no magnesia, although in it the Olivine exists abundantly. Doneyko observes about the mass of Taltal that its Olivine has the composition of prismatic chrysotile. (also Fe: 2 mg) but he has not reported the analysis. Outside is a granular gray mass, amount

about- to 34% whose composition after the deduction of 18% of Nickeliferous iron and 9.7 % of iron pyrites is cited.

The meteoric iron contains

	S. de. Chaca Domeyko	panacera Joy	Taltal Domeyko
Iron	88.5	87.43	88.6
Nickel	11.5-	10.54	11.4
Cobalt-	-	1.67	-
Copper (Sn)	-	0.13	-
Phosphorus	$\frac{-}{100.00}$	$\frac{0.23}{100.00}$	$\frac{-}{100.00}$

These numbers agree with each other and with that which the meteorite of Pallasite of Macama has given. From Foy's statement the composition can be calculated. Silicates. Nickeliferous iron. Iron sulphide Chromium

56.77 56.87 5.43 1.10 = 100.17

The silicates were SiO_2 FeO MgO CaO Al_2O_3

57.28	23.00	11.84	2.47	5.41	= 100.00
-------	-------	-------	------	------	----------

Oxygen ratios

30.55	5.11	4.74	0.70	2.53	
	10.55				
30.55				13.08	

According to this if the acid was too great, then the Olivine and Augite could consist merely of Uni and Si-silicates. Does this meteorite contain, as Breitenbach, free silicic acid?

The bulk of Taltal contains, according to Doneyko

SiO ₂	48.78				
FeO	30.00	6.66			
MgO	7.45	2.98			
CaO	4.82	1.38	11.12		
Na ₂ O	0.38	0.10			
Al ₂ O ₃	8.57		4.01		
	100.00			15.13	

Unfortunately its behavior toward acids is not given. If it contains a certain quantity as is assumed, and this has the composition which Doneyko gives then it could consist of 22.9% of the mass and 77.1% of Augite, were the latter free from magnesia and abounding in Alumina (about 10%) but this is not probable.

But if they contain no Olivine but have augite in it then there would be too much acid, or in other words more acid than was necessary to saturate the ^{existing} small R.O

219

c- Chondrite

From Xovdgos, a little ball. The most numerous and most-common of meteorites. It is distinguished by little nodules which consist of an indefinitely determined silicate of Magnesia and admixed in a fine grained union with the iron according to Rose this class consist of Olivine, chromic iron Nickelliferous iron, magnetite pyrite and a black undetermined mass.

The bulk is in part quite solid, as the Chondrite of Ex libris, Chantonnay etc. in part less dense and almost friable, as the iron of Mauer kirchen Iowa, Bachmut etc. They most frequently have a light-ash gray color, one part passing from grayish to white to snow white on one side, to the other side rarely dark gray and even grayish black, but it is rarely colored uniformly. Sometimes sharp and undecided borders occur in the same piece. as in the chondrite of Bemerdörde

The lighter grains (very seldom crystals) are recognized as olivine and microscopic examination according to Rose shows a fibrous structure near it and dark green transparent grains.

The older analyses (Howard, Vauquelin, Klaproth) have now only an historical interest because, at the most, sometimes after incomplete separation of the meteoric iron ~~the~~ by the magnet the mass by them was examined as a whole. Berzelius 1st tried a method of examining the stone of Sere, Blansko and Chantonmay which was accurate for the separation of single mineral compounds. Many later analyses are manipulated in his way, many however are more or less superficial.

The meteoric iron is seldom in angular or pointed grains, usually in fine laminae, and, even in the mass of the same stone, often unequally divided, on this account its percentage composition is only valued for the fragments examined.

The analyses of it yield from 24 down to 2%

Its composition is demonstrated in Table I. D

The analyses however have for the most part been confined to the iron, nickel cobalt and phosphorus. see page

The part containing nickel ranges from 5.4% 361 of this
(Blauko) to 16%, work. = Blauko ~~aye~~, it is some greater (Dharm-
sala 18.3) Neft 20.95 Buschof 26.5; Honolulu 37.

Iron pyrites is held most for the pyrrho time, although it is not magnetic, it exists as well in the meteoric iron as in the aggregate. In some cases the ^{quantity} ~~quantity~~ is considerable, surpasses even that of the meteoric irons (Honolulu, Krähenberg, Murcia, Arnans, Parnallee) ~~at~~

Chromic iron in the analyses is either directly determined or is calculated from the part containing Fe as FeCr_3O_4 which by its small quantity is admissible. Wöhler chose to determine chromium from the insoluble residue alone but F. A. Cairns believes it is necessary to examine the solution

also for chromium as it often goes into solution. and Rammelsberg admits that the calculation of the Cr from the insoluble residue instead of making a direct determination is not exactly correct.

Table IV gives the relative quantities of the known bodies and of silicates in the examined Chondrite.

The Silicates of Chondrite

The composition of the silicates is directly or indirectly found. In the latter case when a partial analysis is made with HCl, and each one of the parts is examined by itself. Seldom is a joint analysis at the same time well done.

Table V furnishes the composition of the silicates from the Chondrite, arranged according to their silica. That it amounts to a mixture needs no proof.

If one calculates the atomic proportions of the metals (Fe, Mg, Ca, Na, K) and the Si, they will be

found lying between 1:1 & 2:1 the union of the silica, stands consequently between a normal silicate (bi-silicate) and a half silicate (unisilicate). By treatment with acid (in pure HCl) these silicates are found to consist of a decomposed and an undecomposed part; by this means gelatinous silica is separated.

Naturally, by this kind of partially analysis it is proved, that the results disagree, the more so, the more the so called indecomposable silicate is attacked by acids. By the employment of an acid sufficiently strong and allowing a sufficient length of time for its influence, the careful separation of free silicic acid from the rest (the undecomposed) is always a success and we can obtain almost exactly the composition of the latter, but a certain quantity of it passes over in the decomposed portion and upon this possibility, it is to be accepted with some consideration, the critical examination and

estimation. Sometimes one has merely a joint analysis of the silicate. In this case no conclusion upon the relative quantity and the nature of both parts is admissible. However in the case, where the partial analysis is accomplished, the information is sometimes unsatisfactory and we can not draw any conclusion from it. It is here that the following points are significant.

I. The nickelliferous iron must first of all be completely removed. If this is not done there is a loss in the soluble part and this loss appears to enrich the iron. It is the foundation stone to bear in mind that this circumstance in the analysis is often lost sight of; the mechanical separation of the iron will not answer for its complete removal.

II It must be submitted to a special determination for sulphur, in order to be able to calculate the amount of iron sulphide, because otherwise the iron would be estimated as protoxide in the

calculation, and if so the analysis in this respect would not be satisfactory.

When the conditions cited are observed no discrepancy is witnessed in the results, as it shows in many cases, that the decomposed part of the unisilicate of magnesia and iron, is free from lime, alumina and alkalis (i.e. the Olivine is free from etc) and this is corroborated mineralogically by the presence of minerals in many Chondrites.

In general from the great similarity of all Chondrite it is not probable that there is still another decomposed silicate universally diffused with the Olivine. Only in case, where at the same time considerable quantities of alumina and lime appear in this part, could it be ascribed to the presence of anorthite.

In order to show how the figures of the analysis are to be disposed of, if one deduces from it, the decomposed part of the Chondrite is considered to be Olivine exclusively. Berzilius' results with the

Blansko iron are not perfectly satisfactory to
Lammelsburg ~~and~~ ^{but} he hesitates to doubt them.

Blansko. Call A the decomposed part of the
silicate. B the undecomposed part, then is found,

A : B :: 51.5 : 48.5 and 48.9 : 51.1 the mean = 50.2 : 49.8

or 1 : 1 Composition of A.

SiO ₂	33.08		17.64	} oxygen ratio
Al ₂ O ₃	0.33		0.15	
FeO (Mn)	27.39	6.08	21.07	
NiO	0.46	0.09		
MgO	36.14	14.46	0.22	
Na ₂ O	0.86			
K ₂ O	0.43		0.07	
	<u>98.69</u>			

From the quantity of oxygen it follows that
all of the base is olivine. Berzelius perceived this
and the loss from the indetermination of the
sulphur; from which it appeared to him to be want-
ing in the material. An incomplete examination
had furnished him, surely 1.2% of sulphur in A
he had in the mean time convinced himself
that more of it was present. Besides this it would
be well to abstract the 0.46 NiO - 0.37 Ni, that is, with

the corresponding quantity of Fe as nickelliferous
 Since B moreover has given on average 5.3% of
 Al_2O_3 so there must be calculated the quantity of
 the undecomposed part B from the 0.33% Then
 finally the rest is analyzed into R_2SiO_4 and FeS
 then there is, $Ni = 0.37$; $Fe = 6.87$ or 7.24 Nickelliferous iron.

SiO_2	3.62
Al_2O_3	0.33
FeO	0.58
MgO	1.48
CaO	0.14
R_2O	0.06

6.21 B

SiO_2	29.46
MgO	34.64
FeO	7.20
R_2O	1.23

72.53 Olivine

Fe	8.38
S	4.79
	<hr/> 13.17

Nickelliferous iron	7.24
B	6.21
Olivine	72.53
Fe S.	<hr/> 13.17
	<hr/> 99.15

By this only the calculated quantity of S or FeS ^{would} be too great
 as the presence of 1.7 R_2O and Na_2O in the Olivine
 could also excite suspicion.

In this way the stone of Blansko would have yielded

Nickelliferous iron	20.00	(17.15 found.)
Iron sulphide	5.10	
Chromic iron	0.75	
Silicate	<hr/> 74.15	
	<hr/> 100.	

A : B = 36.4 : 63.6

60.2 : 49.8

In the meantime Rammelsberg is of the opinion that the analyses must not be considered as so essential. Suppose for example the NiO belongs to the Olivine, it would then be present as Nickelliferous iron, then comes $23.96 \text{ FeS} = 8.7 \text{ S}$ in the calculation. That is truly improbable. We do not know whether that portion of B, which ^{the acid} could have decomposed was exactly so combined as the rest. In this case we are not in a position therefore, so as to correct the examinations of others by calculation to deduce from it a certain result and must remain satisfied with the facts of the data and with the relative value of the proportion A:B and of the constituents of A. We are permitted to make a correction only when such an inquiry appears necessary.

Table VI yields the proportion A:B, i.e. that the decomposed and undecomposed parts in 100 parts of the silicate. vide page 392

± Series, not-capable of calculation; in consequence

of the method employed it lacked silicic acid.
iron pyrites remains besides, as well as nickelliferous iron.

II Stauropol contains according to Abich a nickelliferous iron with only 4.65% Nickel. If the unsilicate is computed then this lessens its percentage to 1.7%. The details of the analyses were not accessible.

III Chantonmay. The determination of sulphur was omitted by Berzelius as generally the analysis of the nickelliferous iron. The NiO proceeds from nickelliferous iron and if it is the Olivine silicate then it has the computed composition.

IV Pullusk. In Rammelsberg's analysis (c) the result found is the average of three analyses like that calculated to it.

V Borkut. Rammelsberg propounds the query -
Ought there to be much magnesia ^{mitte} ~~in~~ the
alumina?

VI Danville. Smith explains A by the Olivine

which is prevalent in it. On the contrary the larger part of its bulk corresponds to the silicate, there is also nearly 2% of excess. A correction is not possible.

A glance at Table VI. proves that in many Chondrites the silicate almost consists of like parts of A and B or forms the proportion 3:2. Differing from it is this;
In Sauguis = 3:1 In Arnans = 5:1 In Okaba = 3:7

Moreover it is seen that the great majority of this part of the unsilicate is present as Olivine with the proportion $R:Si = 2:1$ that is a compound;

$n = 0.5$ in Ensisheim; 1 in Kakora, Chateau-Lenaud, 1.5 in Arnans, Uden, Guernsey Co; 2 in Montrejean (Harris), Skye, and probably Mauerkirchen, Parnallee, Bachmut; 3 in Mud door, St Mesmin, Tourinnes, Shergotty, Borkut, Utrecht, Linn County; 4 in Chantonnay, Richmond, Aesel, Nashville, Dhurmsala, Daudrum

5 in Mauroopol; 6 in fullusk, Murcia, Tadjera;
8 in Blansko, Klein Wunden, 29 in sanguis.

When frequently an excess of metal is found then this may proceed from the presence of metallic iron and iron sulphide.

Still it varies to a certain extent very considerably from the composition of Olivine, without that, the correction in this case could be made with advantage. as in St Mesmin, Tourmines, Uthet. The analysis has often been reversed by the silicic acid yielded. Chateau - Renard. Skye, Tadjera sanguis, Dhurmsala. Even in this a correction would be hazardous.

The comparison is entirely proper with the Mezo-madaras, analyzed by Wohler. Now, some sodium and Alumina, the composition of the soluble part appears here to be entirely different. The analysis corresponds when $2na = R$ is taken.

The small quantity of lime does not admit of its being considered anorthite and the alumina is not sufficient for a soda-lime feldspar. Precedence must be given our early conjecture about the nature of their silicates to actual observed facts.

The insoluble part of the Chondrite Silicate.

The percentage composition follows from Table VIII *vide page*
 Into the composition of Olivine, Mg. Fe. Al_2O_3 . CaO, 399
 and the alkalis enter. The quantity of SiO_2 varies between 50 and 60% which signifies a composition less basic. In the estimation of an analysis it must not be forgotten that the method pursued biases the interpretation of the results, in particular it is asserted the silicic^{acid} found is certainly often small, because a small portion of the Olivine belongs to it, which would not be completely shown, and again the soluble part is often the source of loss in the analysis. Many times, solubility has been occasioned by the presence of alkalis,

and alumina(?) In this part of the Chondrite the presence of feldspar is acceptable of belief. This assumption contradicts first of all the observation, inasmuch since the microscope nothing which by its cleavage & twin like structure, would indicate a feldspar. For chemical reasons, this cannot be the expression of an anorthite, it can then be treated only as Labradorite or like the preceding soda-lime feldspar. However such a one, least of all, Labradorite, that is one abundant in lime, can not be present because even then, when its particles do not contain considerable lime, the olivine part is dissolved in acid free or almost free from lime and alumina, whilst the Labradorite is not appreciably attacked.

Besides Olivine in meteorites Augite exists, in three crystallographical and chemical forms $MgSiO_3$ = Eustatite; $(Mg, Fe)SiO_3$ = Bronzite; $(Mg, Ca, Fe)SiO_3$ = Diopside or Augite in a restricted sense.

The Chondrite forms after fusion, as Davée has found, exclusively a crystalline and crystalline compound of Olivine and an augite deficient in iron, without a trace of glass metal, as must be furnished by a feldspar. From this we are permitted to draw the conclusion that the

augite is in the insoluble part of the silicate. If we examine to what degree the assumption is warranted by the analysis; in the augitic composition or the bi-silicate $R SiO_3$ is $R:S=1:1$

From thirty six analyses according to Table VIII page 399 this atomic proportion in a fair half of them is completely or so nearly arrived at that no doubt at all can take place as to the true character. Pulluck Richmond Iowa Klein Wanders which Rammelsberg has since shown yields it collectively; Skye, Murcia, Guernsey Is., Montrejean (Harris), Chateau-le-nard, Tadjera, Mauroöpol, Danville likewise and even such ones that contain somewhat more acid, as Cesel

Blansko, Utrecht, Borkut, Bachmatt, Carnallie
Turennes, Seres, are certainly also bi-silicates, if
one applies to the method the troubles and excess
of acid. The alumina belongs to the augites, it
is united with the bi-silicates. The augite of the
muscovite of Hainholz (3.2%) the bronzite of the
meteoric iron of Sodran, the enstatite of the
Meadrite of Bishopville. since meteoric augite
is a border for the rest; in terrestrial bronzite
alumina is very frequent, the crystallized
from the Saacher See, that from the olivine
rock of the Pyrenees. the Eifel and from basalt
is often rich in it, even the drop side of the
olivine rock yields up to 7.4% alumina

Potash and soda are essential constituents of
many members of the augite group: of Usmite
Aegirins, Arvedsonite, all alumina-hornblendes,
also transparent augite (Pitkaranta). In the
bronzite of the meteorite of Shalka, in the ensta-
tite, and lime augite of the meteorite of Buhl

in the Augite of eucrite are shown to be alkalis. Their quantity in the chondritic silicate is often perhaps overestimated and where absent it is well to leave them undetermined.

Table VIII shows the proportions of iron and Mg, (Ca) It is

Fe Mg_5 Pulluok, Blansko, Bachmut.

Fe Mg_4 Ensisheim, Cesel, Chantonnay, Richmond, Mont-réjean, Klein Wenden, Staurobol.

Fe Mg_3 Skye, Utrecht, Borkut, Uden, Pamallee, Iowa
Guernsey Co. Tourmines.

Fe Mg_2 (St-Mesmin), Shergotty, Chateau Renard
Leres, Danville.

Fe Mg Tadjera.

The silicate of Murcia (where even lime is absent) and Kakora are free or nearly free from iron.

The silicate of Murcia is (like that of Bishopville) nearly pure enstatite. Kakora is strikingly deficient in silica, and rich in soda and alumina. Table VIII contains moreover the analyses

proportions of the alkali metals and of Mg (n.b.) which vary surprisingly from 1:32 (Murchell) to 1:4 (Carnallite)

Likewise it is relatively different of the proportions of $Al_2O_3 : 2SiO_2$ which is from 1:50 (Murcia) to 1:6 (Uden)

Line is absent in the silicate of Murcia, St Mesmin, Montjean Harris) In all other cases line enters up to 6% (Padjara even 9%) At present meteoric bronzite (enstatite) sometimes contains line (Manegaum 1.3% Lodraw 0.6 Hainholz 2.7 Zusti up to 2.%) In terrestrial bronzite it is the same

It has not yet been settled whether the undecomposed silicate of the Chondrite consists merely of Bronzite containing line or of Bronzite and Diopside. Besides the great majority of analyses which correspond more or less to the explanation given we find such a one which deviates more than could be possible under the conditions given

if the substance were a trisilicate.

Conceive of Casale and Annas with 70 and 40% of acid and we have Mauerkirchen and Archibald, Mezo madaras and St. Mesmin. Enns being Dundrum and Dhurnsala with large percentage of acid. Mauerkirchen like the former is mistaken for Iowa, and yet what difference in the undecomposed silicate! The composition of their silicates are

	Mauerkirchen	Iowa	these agree also, both are
SiO_2	44.81	46.88	
Al_2O_3	1.84	2.40	
FeO	24.55	17.49	
MgO	26.10	31.36	$\left\{ \begin{array}{l} R_2 \text{SiO}_4 \\ 2R \text{SiO}_3 \end{array} \right\}$
CaO	2.28	1.41	
Na_2O	0.26	0.46	
K_2O	0.16		
	100.00	100	

and it is no doubt barely confirmed in the analysis, that the augite portion contains the first excess of acid beyond measure. Manifestly this consideration is also applicable to the one which remains over

Mezo - Madaras. The composition of the silicate

in this stone examined by Wether and others
 son) which, according to G. Rose, is very similar
 to that of Seres, it differs from that remaining,
 in this way that the whole is a resillical.

The proportion of both parts is = 62:38%, the
 decomposed part is destitute of iron, contains
 an abundance of Alumina and Soda, it corre-
 sponds very nearly to

the indecomposable

but almost a trisilicate $R_2 Si_3 O_8$

APPENDIX TO. CHONDRITE

Meteorite of Tula. This was found at Netschaewo
 in the vicinity of Tula and recognized by Auerbach
 as a meteoric iron to contain in its interior one of
 the chondrites, approaching the character of a
 Buccia, a gray mass with glittering scales of
 Nickelliferous iron, according to Auerbach it con-
 tains the following

Nickeliferous iron Chromic iron Silicate

16.70

0.11

83.19 = 100.00

I Composition of the entire silicate. A the decomposed

B the undecomposed part.

	I	A	B
Silicic Acid	38.28	35.49	58.97
Alumina	10.05	8.52	20.96
FeO	32.46	35.35	11.39 (including 1.83 NiO)
MgO	16.91	19.00	2.02
CaO	0.81	0.80	0.92
Soda	1.24	0.84	4.08
Potash	0.25	.....	1.66
	100.00	100.00	100.00

A : B :: 87.7 : 12.3

The silicate of Tula is so deficient in silicic acid as to vary but little from chondrite but rich in alumina

(Alessandria is uncertain) and whilst the quantity of the silicate of the latter lies generally between mono- and Bi-silicate it appears here as a mono-silicate

(Oxygen of RO and U_2O_3 : SiO_2 = 19.26 : 20.41)

Also the decomposed part A, though naturally also a monosilicate (Oxygen 19.89 : 18.93) is not Chlorine

as Auertach announces, for it contains 8.5% of alumina, and it was a weak hypothesis to con-

sider it as a representative of R.O. The undecomposed part B, expresses, whilst in A it lacked somewhat in SiO_2 and its quantity in the proportion is higher, if possible a bisilicate (Oxygen of R.O. : Al_2O_3 : SiO_2 - $4.93 : 981 : 31 = 45 = 14.74 : 31.45 = 1.21$;) but nevertheless it would in any case, be impossible to find Augite. The nature of the silicate remains doubtful.

Carboniferous Meteorites

Very peculiar is the black, partly solid, partly loose stone of Ulin, Bokkeld, Kaba and Agneil. It consists of considerable Alluvine, little bronzite sulphide of iron, chromic iron, and nickeliferous iron and contains amorphous coal and an organic carbonate. Besides, water is yielded upon heating.

This, as a soluble sulphate, shows itself as disintegrated upon the surface, it is manifestly a secondary compound, the latter has been induced by the oxidation of its iron sulphide. The iron of it

like that of former unply proved nickeliferous is changed into protoxide, the carbon is perhaps separated by the decomposition of the carbonate by its descent. The latter is now present only in a small quantity and the examination discloses but little about its nature. By fusion of the stone of Alais, Bokkeweld and Orqueil, Daubree obtained gray or green fibrous masses, with enstatite or trypsilite crystals.

Alais.

This one fell on the 15th march 1806 and has been described by Berzelius. It is formed of a black, friable mass, with white points and efflorescing salts. In water it crumbles to a gray green pulp of an earthy character. On heating it yields water, sulphurous acid and a dark brown sublimate. B.B. it fuses with difficulty to a black slag. The magnet abstracts from it dark parts without loss (magnetic iron?) Water dissolves from the powdered salt-

sulphate of magnesia, lime, nickel, soda, potash a little ammonia and organic matter. From which the powder dried at 100° showed water 11.5%, water free salts, and the magnet 13.3%, but still much of the rest belongs to that.

In the magnetic part are found white shiny scales, metallic iron, small quantity of which does not permit an examination for nickel. The rest was protoxide and a little sulphide of iron.

The powder dried at 100° , lixiviated with water & air upon digestion 88.15 black residue, 0.94 grayish brown sublimate, $4.33\text{H}_2\text{CO}_3 + 6.58\text{H}_2\text{O}$. The black residue is treated with HCl. The largest part is decomposed and the solution contains sesqui- and protoxide

SiO_2	31.22	
Al_2O_3	2.36	
Fe_2O_3	32.54	
NiO	1.38	
MgO	22.21	
CaO	0.23	
$\text{SnO}_2(\text{Cu})$	0.80	
Fe_2O_3	0.63	
insoluble	8.69	100.00

If now 100 parts of the soluble salt-free from other matter contains 15% of magnetic matter, then the 88.15% of the black residue yields 17% of it. If one accepts this as pure Fe_3O_4 then it corresponds to 17.6 of this and when it originates from Nickelliferous iron, then this has the constituency of,

Iron $\frac{12.32}{18.40} = \frac{91.94}{100.}$		and the decomposed silicate is	
Nickel $\frac{1.08}{18.40} = \frac{8.06}{100.}$		SiO_2 44.94	23.97
		Al_2O_3 3.40	1.59
		FeO 19.36	4.30
		MgO 31.97	12.79
		Lime $\frac{0.33}{100.}$	0.09
			17.15
			} oxygen ratios

From these figures, generally from the percentage of alumina, it follows that the whole consists of Olivine and Augitic matter. Berzelius has also examined the 8.7% of the insoluble part. It consists of carbon, chromic iron, and a silicate of iron.

Nickel, magnesia, and alumina, but the small quantity prevents a trustworthy determination. The conclusion is well founded, that the meteorite of Alais, aside from its carbonaceous parts, consists

or rather consisted of ilmenite predominating,
 bronze, nickeliferous iron, and iron sulphide,
 for in consequence of its porous nature, it has
 been altered by oxydation, it has originated from
 sulphate, protoxyd of iron and oxyd of Nickel
 Bokkeveld at Tolbagh in Capeland.

Fell on the 13th of October 1838 at first described
 by Faraday, then by Harris and lately by
 Rammelsberg. Faraday finds 6.5% of water,
 Rammelsberg finds at 140° ; 3.6% at a stronger
 heat even 11.5% collectively 15.24% of water (and
 perhaps also carbonic acid) Upon heating in a
 closed vessel, sulphur is volatilized, ~~by burning~~
 turns to sulphurous acid gas. As a whole this
 meteorite contains (after deducting the
 water and carbonaceous matter, the
 first analysis a by Faraday the second
b by Harris.

SiO ₂	30.91		31.40
Al ₂ O ₃	5.58		2.09
FeO	35.53		26.77 (84.8 in the whole)
NiO	0.88		1.66
MgO	20.54		22.64
CaO	1.75		1.73
* K ₂ O + Na ₂ O	trace		1.25
Sulphur	4.53		3.45
Cr ₂ O ₃	0.75	Iron	6.04
		Cr ₂ O ₃	0.77
		FeO	0.36
	100.47		98.16

* Engellbach has also found Sr and Li by spectrum analysis. The powder contains only a small amount of magnetic particles, with HCl only a trace of hydrogen is evolved, no sulphuric acid. hydrogen. Harris has found that the acid solution of iron and magnesia contains, and Wöhler has made it probable, that the decomposed part is Olivine. Aqua Regia however has been chosen for the decomposition, the statement is unaccompanied by the results, Rammelsberg has thought fit to make a partial analysis of the meteorite. The black mass was submitted for this examination, which was obtained by strongly heating the powder excluded from the air.

treated with a hot solution of mercury chloride, it gave an extract which contained only traces of iron besides MgO , lime and nickel (0.86% of NiO); one perceives that the original nickeliferous iron in the experimental mass entirely disappears and is changed into protoxide of iron. Therefore the ashes give with HCl a yellow color, both oxides of iron arising from fluidity. If we calculate the oxide from the chloride of mercury solution, the excess in it, then is obtained

Silicic acid. FeO (mn) NiO MgO CaO , insoluble silica

28.94 32.78 1.86 30.50 1.40 4.49

In what determined by Harris the sulphur was

8.45, Fe 6.04 = FeO 7.76 If the silicate is

regarded as Olivine there will then remain the oxide of iron and nickel of the former nickeliferous iron and indeed

can.

Fe	9.56	} 11.05 =	{ 86.8
Ni	1.46		
Fe	6.04	} 9.49 Fe.S	{ 39.36
S	3.45		
SiO ₂	28.94	} 73.53	{ 17.26
FeO	12.69		
MgO	30.50		
CaO	1.40		
			100.

The Alumina is approximately ;

The undecomposed part has also been examined by Rammelsberg, although its quantity was so small.

SiO ₂	52.00	} Oxygen ratio.
Al ₂ O ₃	7.83	
FeO	17.10	
MgO	23.07	
Si	traces	} 13.03
Alkalies		
		100.

With due allowance for the imperfections of such an analysis (with only 0.15 grammes of substance) one can conclude, that ~~this~~ portion is bronzite and certainly

By calculation the composition is yielded SiO₂ 31.28 Al₂O₃ 0.35, FeO 33.55 NiO 1.86, MgO 31.53

CaO 1.40 which only varies by its greater amount of magnesia, from the former research.

There is no sulphuric acid evolved by solution as Wöhler assumed, there could be no FeS present and supposed the presence of a compound $\text{NiS} + \text{Fe}_2\text{S}_3$. According to Rammelsberg's views the sulphur was by all means originally present as, and entirely as FeS , but still one portion is free, one other has the form of sulphate, whilst Fe_3O_4 originated, the little remaining is however as FeS in the mass, these do not evolve sulphuretted hydrogen with acid, because iron oxide is present in excess. According to this view, the meteorite of Bokkewold consisted originally of

nickelliferous iron	Iron sulphide.	Olivine.	Tronzo.	Atomic Fe
11.00	9.5	73.5	4.5	about 1

What now happens to the carbonaceous substance, the stone yields by heating a bituminous odor, alcohol abstracts a yellow white substance, which

is precipitated by water, it is fusible and decomposes by heat with separation of carbon. It is mixed with amorphous carbon. According to Hornes the latter amounts to 1.67 and that substance to 0.25. According to later researches of Wöhler there is present 2% of carbon.

Kaba at Debreczin, Hungary.

Fell on the 15th of April 1857. Dark gray, earthy mass, consisting of many globules a white mass and a gray mineral, that one is hollow in the middle, and under the microscope can be distinguished colorless crystals and black particles.

Magnetic particles would scarcely be present in the experimental trial, although the stones of other places contain according to Hornes description, metallic particles.

Wöhler has determined the composition of the stone, and from the estimation supposes a nickeliferous iron with 32% of nickel. This appears to be too high a percentage. If accurate

is had to the average = 12% of nickel, then we obtain,

Fe	Ni	Cu	S	Fe	SiO ₂	Al ₂ O ₃	FeO	MgO	CaO	K ₂ O
10.47	1.43	0.01	1.48	2.22	35.71	5.61	17.78	23.35	0.69	0.32
Nickelliferous iron			Pyrrhotine		Silicate			Chromite		
11.91			3.70		83.46			0.93 = 100.0		

In the silicate R is : Si = 1.4:1 the whole is then manifestly Olivine and Bronzite.

Besides these inorganic constituents there is a paraffine like body, easily fusible carbonaceous compound in union with amorphous carbon.

Wöhler could discover no metallic particles in the fragment which he examined, but ^{on} one side he found grouped together a number of shining metallic grains and he concludes from this that it must be very unequally admixed. The following analytical results show only the nature of the earthy dark gray part of the stone.

In 100 parts of this there was found.

$$\begin{array}{r}
 \text{Wt} = 100 \\
 \text{C} = 7.58 \\
 \text{Fe} = 2.88 \\
 \text{Ni} = 1.37 \\
 \text{Cu} = 0.01 \\
 \text{Cr, FeO} = 0.89 \\
 \text{FeO} = 3.55 \\
 \text{FeO} = 26.20 \\
 \text{MgO} = 22.39 \\
 \text{Al}_2\text{O}_3 = 5.38 \\
 \text{CaO} = 0.66 \\
 (\text{Na}_2\text{O}) \text{K}_2\text{O} = 0.30 \\
 \text{MnO} = 0.05 \\
 \text{SiO}_2 = 34.24 \\
 \left. \begin{array}{l} \text{Co} = \dots \\ \text{P} = \dots \\ \text{Unknown} = \dots \end{array} \right\} \text{in inestimable quantities.} \\
 \hline
 98.50
 \end{array}$$

It is a mixture of bases, ^{one} which by chlorates ^{is} easily decomposed, ^{the} Magnesia, protoxide of iron - silicate and of silicates which by this acid are not decomposed. it contains besides nickelliferous iron impregnated with cobalt and phosphorus, iron sulphide, chromic iron stone and an unusually black constituent, amorphous carbon.

The amount of metallic iron could not be directly determined but was computed from the quantity of nickel. with the assumption that the stone was one of the most-common meteorites

and that it contains nickeliferous iron soluble with difficulty in hydrochloric acid. There was only any traces of hydrogen evolved with this acid.

The acid dissolved however considerable in the cold and this solution then contained considerable magnesia and protoxide of iron, the remainder would consequently contain the iron, assuming it as united with the sulphur, and brought into the calculation as protoxide, the whole would contain 34.57 FeO, the sulphur found amounts to 1.42% corresponding to 3.55 pyrrhotine, that the stone contains this and not mono-sulphide of iron is probable from this, that with hydrochloric acid, heated, it evolves sulphuretted hydrogen and that the residue is then free from sulphur. Cobalt and phosphorus were found with certainty but could be determined only with the employment of more material. 1.680 grms of stone gave 0.036 carbonic acid.

ORGUEIL DEPT. TARN ET GARONNE

Fell on the 14th of May 1864, a black, porous friable mass which crumbles in the water. Examined by Cloz and Pisani. Dried at 110° it yields

	Cloz	Pisani.
Water	7.82	organic matter } 13.89
Ammonia	6.10	
Humates	7.41	
	<u>21.33</u>	

It dissolves by water according to that one 6.41 according to this one 3.35% of salts, sulphates of Mg, Ca, Na and K.

It exists only in the whole analysis. If the 2.33% of sulphuric acid (Cloz) is combined as a sulphate of K, Na, + Ca, in reserve, it assumes a pyrrhotine and a nickelliferous iron containing 12% of nickel, then we obtain

(Co)	Iron 15.47	17.58	Nickeliferous iron	SiO ₂	26.03	} 41.91 Silicates
				Al ₂ O ₃	1.25	
	Sulphur 4.65	11.62	Pyrrhotine (Mn)	FeO	4.83	
				MgO	8.67	
	Iron 6.97	0.35	Chromic iron	CaO	1.13	
	FeO 0.11					
	Cr ₂ O ₃ 0.24					

Pisani gives no nickel and finds 15.77 Fe, Fe_2O_4 ,
 0.49 Fe, Cr_2O_4 , 13.43 FeS, 26.08 SiO_2 , 0.90 Al_2O_3 , 8.14
 FeO (mn), 17.0 MgO, 1.85 CaO, 2.26 Na_2O , 0.19 K_2O

The analysis of the silicate however does not agree,
 inasmuch as it gives

	Cloëz	Pisani
SiO_2	62.1	46.2
Al_2O_3	3.0	1.6
FeO	11.5	14.4
MgO	20.7	30.1
CaO	2.7	3.3
Na_2O}	.....	4.0
K_2O}	.....	0.4

Pisani's analysis only deserves confidence, for it
 makes the silicate of this meteorite appear like
 that of many chondrites as Olivine and augitic
 matter. According to Cloëz there is found
 in this mass small crystals of $(\text{Mg}, \text{Fe}) \text{CO}_3$
 The black ulminic matter is insoluble in dilute
 caustic potash.

Hessle, Sweden.

This stone fell on the 1st of January 1869 three miles from Upsala. A light gray porous mass of chondritic structure with pointed grains glittering like silver. Resembles the stone of Mont régian. Composition of the whole according to the analyses of

	I Lindström	II A. Nordenskiöld	III
Meteoric iron	18.96	17.76	18.63
Iron sulphide	5.17	1.02	trace
Chromic iron	0.04	0.52 ⁽¹⁾	0.85 ⁽¹⁾
Silicate	75.83	80.70	80.52
	<u>100.</u>	<u>100.</u>	<u>100.</u>

(1) contains carbonic acid

Composition of meteoric iron

Iron	88.23	88.85	87.29
Nickel	11.34	11.15	12.61
Cobalt	0.11	trace	trace
Phosphorus	0.32	.....	.....
	<u>100.</u>	<u>100.</u>	<u>100.</u>

It is thus about Fe 8 Ni like the iron of many Chondrites. Composition of the Silicate, Lindström, SiO₂ 48.19, Al₂O₃ 3.11, FeO (mm) 14.75, Mg. O 30.37, lime 2.35; Na₂O 1.23 = 100.

This combination approximates to that of many chondrites and agrees, among others, exactly with Oesel. The atomic ^{proportion} as is usual $R:Si = 2:3$, thus indicating an uni- and bisilicate. The proportion of both parts A and B is estimated as a mean of four trials $50:16:49.84$ or nearly as 1:1

Composition of A and B

	A			B		
			oxygen	LINDSTROM	oxygen	NORDENSKIÖLD
SiO_2	41.40		22.08	60.06	32.03	59.16
Al_2O_3	0.06	0.03		5.86	2.74	3.00
FeO	17.34 ⁽¹⁾	3.85		8.29	1.84	10.48
MgO	38.72	15.49	19.98	19.28	7.71	21.72
CaO	1.57	0.45		4.10	1.17	8.69
N_2O	0.63	0.16		2.41	0.62	3.00
						(2.64)
						0.68

(1) including 0.21% NiO .

It is obvious that A is olivine, and certainly a compound in which $Fe:Mg = 1:4$ (like Chantonmay, Oesel, Richmond etc).

B resembles the corresponding portion of the chondrite of Insheim, Oesel, Blansko but also Pultusk according to von Rath's analysis. As for the latter part the percentage of acid, by Rammelsberg's examination is reduced from

60.1 to 56.2%. none of this part can be regarded as bisilicate (bronzite) as it might be even in the fall of Hesse. A revision of this point is to be desired. Nordenskiöld's assumption of labradorite (or anorthite) is entirely unsatisfactory.

III SILICATES

Meteorites consisting only of silicates are often free from meteoric iron, but sometimes they contain a little. The accessory components found are iron sulphides (sometimes in the form of pyrrhotite) seldom calcium sulphide (in the stone of Busti) and very commonly chromic iron.

The silicates are

- a Olivine, that is, the unsilicate of Mg & Fe
- b Members of the augite group, therefore bisilicate and indeed Enstatite. (Mg, Bronzite (Mg Fe) Diopside (Ca Mg) and Augite proper (Ca, Mg, Fe)
- c Anorthite, i.e. unsilicate of Al & Ca, the only recognized member of the feldspar group which

now.

Olivine, Eustatite and Troilite form by themselves the mass of meteorites exclusively or almost so. The rest occurs by itself or with that together.

1 Olivine (Chassignite)

There is up to 1870 only one known representation, the stone which fell in 1715 at Chassigny near Langres, a loose, finely grained, greenish yellow mass. B.B. fusible with difficulty, grains arising from chromic iron. Density = 3.57 Damour. Is decomposed by acids, An early analysis by Vauquelin (a) and a late one by Damour (b) are given, after deducting 2.95 and 4.87 % FeO , Cr_2O_3 respectively

	a	b		
SiO_2	36.5	37.10		19.79
MgO	34.4	33.39	13.36	
FeO	29.1	27.70		19.74
MnO}	.....	0.47	6.38	
K_2O}	.....	0.69		
	<u>100.</u>	<u>99.35</u>		

It is therefore $\text{Fe} : \text{Mg} = 1 : 2$ this olivine has the composition Fe_2SiO_4 , $2 \text{Mg} \cdot \text{SiO}_4$

3 Si =	84 =	SiO ₂	37.14
4 Mg =	96	MgO	33.06
2 Fe =	112	FeO	29.75
12 O =	192		
	<u>484</u>		<u>100.</u>

It is the same union, as that given to the Olivine of Sasbach (Hyalosiderite) according to Damour the whole consists of Olivine 95.13 Chromic iron 4.87 = 100. Damour believes that in the latter ~~it~~ ^{some} was contained ~~an~~ Augitic matter.

Lehmann had remarked before the very fine metallic particles in the mass and Rose also observed single microscopic grains and cubes of a yellow substance having a metallic lustre, which is insoluble in HCl. Nauguelin has fruitlessly searched for Ni.

2. Olivine and Bronzite (Shaktite)

One such compound, with a little Chrome iron, is in the stone that fell on the 30th of November 1850 at Shalka, in Hindostan. A granular mass, in which the dark gray green part is cleavable in a certain direction, and light, greenish

yellow grains can be separated. That belongs to Bronzite. According to Haidingers observation it appears to be easily cleavable, in conformity with the augite prisms. Besides, there are grains and octahedra of chromic iron. The powder is partly decomposed by HCl. B.B. is scarcely fusible (G. Rose)

C. Hauer has furnished an analysis of this meteorite which, nevertheless according to later results of Ramsdells bag show to be incorrect. According to the latter it consists of

Bronzite 86.43 Olivine 10.92 Chromic iron 2.11 = 99.46
The composition of both silicates was found to be,

SiO ₂	35.17	55.55
MgO	29.03	27.73
FeO	35.80	16.53
Siine	.....	0.09
	100.	Na ₂ O 0.92
		100.82

They are therefore

Olivine $3 \text{Mg}_2 \text{SiO}_4$, $2 \text{Fe}_2 \text{SiO}_4$ Bronzite 3MgSiO_3 , FeSiO_3
calculated to

	Olivine	Bronzite
SiO ₂	36.23	55.586
MgO	28.99	27.78
FeO	34.78	16.66
	<u>100</u>	<u>100.</u>

3. BRONZITE

Up to the present time only one meteorite of this kind is known, the stone fell July 26, 1843 at Maneyaum in Hindostan, its nature has been ascertained by Maskeyne. It consists of greenish yellow, reddish transparent grains in that itself seems to be the measure of the angle of Augies (Bronzites). Its density is 3.198
a the analysis of these grains. b. the whole after the deduction of 1.03% of FeO, Cr₂O₃

SiO ₂	55.70		29.70	54.19		28.90
MgO	22.80	9.12		23.56	9.42	
FeO	20.54	4.56	14.06	20.68	4.59	14.44
CaO	1.32	0.38		1.58	0.43	
	<u>100.36</u>			<u>99.93</u>		

The whole mass is thus like that of the grains examined Fe Si O₃, 2 mg SiO₃

3 Si = 84	=	SiO ₂	54.19
2 Mg = 48		MgO	24.10
Fe = 56		FeO	21.65
90	=	<u>100.</u>	

4. instatite. (Chladnité)

We comprehend conditionally by these names, which are so distinguished and very similar to one another, however they are together not completely like the stone of Bishopville and Rusti

I BISHOPVILLE

This stone fell on the 25th of March 1843, at Bishopville in S.C. it is distinguished by its light blue to white color, indistinctly crystalline nature, and single white grains in the soft mass, which are cleavable in a certain direction.

Shepard, who has obtained possession of the stone, has described and examined it, we possess a careful description by G. Rose of its outward appearance. According to the first it has often very large snow-white crystals which form the chief mass of the stone, a feldspar, according to G. Rose, it is not sufficiently formed. to express an opinion about this, which does not correspond to its structure. Its density

according to Shepard is 3.116, according to Sartorius who compares its form with that of Wollastonite = 3.039

Of the chemical properties of these silicates which Shepard discovered, from more than $\frac{2}{3}$ of the stone (in another place he says ~~not~~) quotes of it B.B. it fuses without difficulty to a white enamel. Its behavior toward acids is not mentioned. G. Rose found however that the substance B.B. is fusible only on the edges and is on slightly attacked by hot HCl.

According to Shepard's statement it consists of the mineral called chladnite by him, of 70.41 SiO_2 , 28.25 MgO and 1.39 Na and was according to that a trisilicate.

Later Sartorius gave as the composition of the white mineral. Silicic acid 67.14 Mg 27.11

Sine 1.82, Alumina 1.48. Iron oxyd 1.70 Water 0.67

Sartorius calculated this as trisilicate of magnesium

and a lime-alumina silicate combined as Labradorite. The first compares it to Wollastonite, which he maintains is a trisilicate of lime, what is known as entirely incorrect (it is a ~~basaltic~~ ^{basaltic} ~~basaltic~~).

These analytical results are evidently entirely erroneous. ^{Rapin's pag} has ~~it~~ to be sure not been able to examine the crystalline mass by itself but has analyzed only the whole mass of the stone owing to lack of material, but so different results are obtained, that it is clear, that the crystals which form nearly all of the mass could not have the composition stated by Shepard and Saxtorius. By treating the whole with HCl we abstract about 5% of bases which consist, $\frac{2}{3}$ of MgO, in the rest of iron oxyd and lime alumina is not in it. After all this is then neither the expression of anorthite nor of Labradorite. Accordingly the analysis of the mass of the stone yielded in that case after the deduction

of the iron oxide which evidently arises from the scales of meteoric iron, the same, and loss by ignition, reduced in like manner they are placed opposite each other

	Rammelsberg		Smith.	
	a	b	a	b
SiO ₂	57.52	58.84	59.97	= 60.21
Al ₂ O ₃	2.72	2.78	.....	.....
MgO	34.80	35.60	39.33	39.49
Li ₂ CO ₃	0.66	0.67	.....	.....
Na ₂ O	1.14	1.16	0.74	0.74
K ₂ O	0.70	0.71	.....	100.44
FeO (Mn)	1.45	99.76	0.40	
Loss by ign.	0.80		100.44	
	99.79			

Now the oxygen is

	Rammelsberg		Smith	
	a	b	a	b
SiO ₂		31.38		32.11
Al ₂ O ₃		1.30		
MgO	14.24	14.85	15.79	15.98
CaO	0.19		.....	
Na ₂ O	0.30		0.19	
K ₂ O	0.12			

Smith's and Rammelsberg's researches then, teach that the mass on the whole is a bisilicate, and the former certainly had pure crystals at his disposal. Rammelsberg thinks there is no doubt ^{that} the principal mass of the Bishopville

288
stone is Eustatite = $MgSiO_3$

$SiO_2 = 60\%$; $MgO = 40\%$

In addition to the predominant substance appears to be something like an aluminous silicate, which perhaps contains lime and alkalis, but this is, as already remarked, no feldspar nor anorthite, and also the white grains in the mass Shepard states to be Anorthite, this is not, as G. Rose has shown. In that Rammelsberg removed the fine stone powder by washing and he was convinced that in the lighter parts more alumina and lime and less MgO is contained than in the heavy part, but the nature of the silicates must be settled by further research.

The stone of Bishopville contains on the outside but little meteoric iron, of which the largest part has but passed into the oxide and the iron molds have been produced in the mass. Pyrrhotite and chromic iron are also found, as that calcareous

249
sulphide (Oldhamite) proved by Maskelyne in the stone of Busti, accordingly the latter occurs in it. Daubree states, that the stone of Bishopville is changed by fusion into the crystalline enstatite, in which there are but few Olivine crystals. Analyses and measurements of this must first be confirmed, as this, taken from the Olivine, according to the former condition is securely established.

5. ENSTATITE AND DIOPSIDE

(Meteorite of Busti)

This stone fell on the 2nd of December 1852 between Gorukpur and Feizabad in Hindostan, the largest part of it is now in the British Museum, it has been accurately examined by Maskelyne. It has a great resemblance to the Bishopville stone in many ways. Its principal mass is a crystallized silicate partly colorless and translucent, partly gray, transparent and

opaque, in consequence of intermixing. Some of its angles ($91^{\circ} 30'$, $133^{\circ} 35'$ and $138^{\circ} 26'$) indicate beforehand an augitic mineral. By the most careful selection there has been separated three portions

portions	a Dark gray Tabular	b white translucent	c gray Semi transparent
SiO ₂	58.44	59.13	57.86
MgO	41.23	39.40	39.52
CaO	.....	1.70	2.07
NaO	0.91	0.36	0.67
K ₂ O	0.39	0.33	0.57
	<hr/> 100.97	<hr/> 100.92	
after deduction of Fe ₂ O ₃	1.43	1.18	0.48

The principal mass of Busti is thus like that of the Bishopville bisilicate of magnesia, $MgSiO_3$ or enstatite. The iron oxide is deducted, because the greater part of it is mixed with metallic iron.

In the mass of enstatite, abundant in the conical concretions of the Aldhamite and in whose proximity are violet gray crystallized grains having single faces. The troublesome measurement proves by the optical examination and analysis that

it is a double and single ~~and~~ ~~mixed~~
lime - magnesian augite or Diopside.

approximately found		Diopside
$a:c = 75^{\circ} 30'$		74°
$b:c = 81$		$80 30'$
$b:a = 132\frac{1}{2} - 134$		$133 32.5$
$b:b = 85 - 86\frac{1}{2}$		$87 5$
$a:o = 125\frac{3}{4} - 126\frac{1}{2}$		$126 10$

The plane of the optic axis is the most symmetrical and the two mean axes make with the vertical upon a & c an angle of $52^{\circ} 30'$ and $22^{\circ} 45'$ thus as with Diopside. The mean of two analyses was (after deducting 0.54 of iron oxide oxygen, a continuation

SiO ₂	56.79		29.75	$\left\{ \begin{array}{l} 5 Mg SiO_3 \\ 3 Ca SiO_3 \end{array} \right\}$ must
MgO	23.46	9.38	15.26	
CaO	20.09	5.74		
Na ₂ O	0.55	0.14		
	<u>99.89</u>			contains 56.6 SiO ₂ , 23.6 MgO

contains 56.6 SiO_2 , 23.6 MgO

and 19.8 Lime. Maskelyne conjectured rightly that the pure substance is still richer in lime, there is some enstatite mixed with its mass. It is probable that this pure augite approximates to the terrestrial Diopside $\left\{ \begin{array}{l} Mg SiO_3 \\ Ca SiO_3 \end{array} \right\}$

Oldhamite. In the stone of Busti (and, according to Maskelyne, also in that of Bishopville) formed

in the Augite, or in the enstatite or in both occurs brownish yellow conical concretions which consist of CaS . The substance is broken one way cleavable conformably to the surface of the cube, has a density of 2.58, it yields upon boiling with water, like artificial CaS , products of decomposition, soluble easily in acid, with evolution of sulphuretted hydrogen, on the upper surface by the secondary influence of the air it is covered with sulphate of lime. Two analyses yield

	¹	²	or	¹	²
CaS	89.37	90.25		96.5	94.2
MgS	3.25	3.26		3.5	3.4
FeS}	.....	2.30		.....	2.4
S. CaO	3.95	4.19		<u>100</u>	<u>100</u>
C. CaO	3.43	.....			
	<u>100</u>	<u>100</u>			

In the Aldhamite are found small, gold yellow, regular octahedra that are called Estornite whose chemical nature up to the present time has not been ascertained.

Maskelyne has also examined the mass of the stone and the bulk rich in augite from the presence of the separated Aldhamite. The treatment

with HCl gave A decomposable part 16.87
B insoluble part 83.13
100.

	A	B
CaSi	4.37 ⁽¹⁾	
SiO ₂	6.51	46.36
MgO	5.05	23.27
CaO	0.02	12.37
Na ₂ O	0.12	0.47
K ₂ O	0.10	0.14
Fe	0.13 ⁽²⁾	0.89 ⁽³⁾
	16.30	83.50

(1) of which 0.234 was determined
as 0.442 CaSiO₄
(2) Determined as 0.19 Fe₂O₃
(3) Including 0.02 Si₂O

B shows the basaltic composition (Oxygen = 13.0 : 24.7) with a deficiency in acid, but nevertheless it is admissible as Augite and Eustatite

A on the contrary (In 100 = 55.17 SiO₂, 42.8 MgO, 0.17 CaO, 1.02 Na₂O, 0.84 K₂O) is evidently decomposed portions of eustatite, what also harmonizes with the particular research which Maskelyne had undertaken upon the behavior of this augitic composition toward acids. Finally the stone of Busti does not lack meteoric iron, troilite and chromic iron, the latter in small shiny octahedra. A

grain of meteoric iron gave

Fe	94.95
Ni	3.85
Schreibersite	1.20
	100.

$$= \begin{cases} \text{Fe} & 0.83 \\ \text{Ni} & 0.23 \\ \text{P} & 0.084 \end{cases}$$

That is, therefore Ni Fe₂₆, thus in 100 - 13.1 Fe
19.3 Ni 7.0 P. would compound about to P₂ Ni₃ Fe₁₂

AUGITE AND ANORTHITE (EUCRITE)

This division of meteorites belongs to that best known, it consists namely of a granular crystalline compound of Augite and Anorthite with a small quantity of Pyrrhotine and metallic iron. It was long ago proved by G. Rose that the Eucrite of Juvenas contained in the cavities of the mass, crystals of dark brown Augite, like that of basalt and lava, little, inappreciable crystals of a feldspar which he declared to be Labradorite and contained also single well formed crystals of Pyrrhotine. Shepard considered later, the feldspar as anorthite, but first by Rammelsberg's analysis of the Eucrite of Juvenas and of Stannern is this rendered a matter of fact. Salty Lang has performed a measurement of it. G. Rose has still later described in detail the mineralogical nature of Eucrite the result of microscopical observation of powdered filings.

B. 3. Ecrite fuses easily, even when the component parts by themselves. Not separate fully, almost-completely. The anorthite gelatinizes, the Augite is scarcely attacked. The ecrite of Stannern and of Juvinas has been examined by Rammeisberg, that of Petersburg Lincoln Co Tenn, is by Smith although incompletely. Composition

	Augite	Anorthite	Chromic iron	Pyrrhotine
Stannern	66.62	34.47	0.64	.....
Juvinas	63.75	34.12	1.34	0.25
Petersburg	68.6	30.0	.....	0.6

Composition of the Silicates

	SiO ₂	Al ₂ O ₃	FeO	MgO	CaO	Na ₂ O	K ₂ O
Stannern	48.30	12.65	21.05	6.87	11.27	0.62	0.23
Juvinas	48.33	12.57	19.87	6.44	10.23	0.63	0.12
Petersburg	49.21	10.05	20.41	8.13	9.01	.....	0.83

Composition of the soluble part

Stannern	16.16	10.93	0.92	0.39	5.94	0.40	0.17 = 34.98
=	46.17	31.23	2.63	1.11	17.00	1.14	0.50 = 100
Juvinas	15.41	12.40	1.09	0.13	6.64	0.37	0.12 = 36.52
=	42.22	33.97	3.00	0.35	18.19	1.02	0.33 = 100

already these numbers leave no doubt—that this portion is anorthite but there the acid on the one hand has left—some of this compound undecomposed, as the Alumina and alkalis in B show, on the other hand some Augite (B) would be decomposed which indicates Fe and Mg in A, then we can calculate the

quantity and composition of the anorthite from that of the silicates chiefly (A+B) in which we turn aside from the alumina and alkalis

	SiO ₂	Al ₂ O ₃	CaO	Na ₂ O	K ₂ O	
Stannern	14.77	12.65	6.20	0.62	0.28	= 34.47
=	42.80	36.70	18.00	1.80	0.70	= 100.
Juvinas	14.62	12.55	6.20	0.63	0.12	= 34.12
=	42.84	36.78	18.18	1.85	0.35	= 100

Composition of the insoluble part-
A. found directly.

	SiO ₂	Al ₂ O ₃	FeO(Mn)	MgO	CaO	Na ₂ O	K ₂ O	
Stannern	32.14	1.72	20.13	6.48	5.33	0.22	0.06	= 66.08
	48.70	2.60	30.45	9.77	8.06	0.33	0.09	= 100.
Juvinas	32.92	0.15	19.48	6.31	3.59		0.26	= 62.71
=	52.50	0.24	31.07	10.06	5.73		0.40	= 100.

B. Calculation.

If also in this place the analyses direct and the isilicate values of these portions are placed out of the question or disregarded, then we also still have its quantity and ^{composition} ~~calculation~~, from the combination of the silicate after deducting the erroneously calculated anorthite

	SiO ₂	FeO	MgO	CaO	
Stannern	33.53	21.05	6.87	5.07	= 66.52
	50.40	31.64	10.32	7.62	= 100
Juvinas	33.71	19.57	6.44	4.03	= 63.75
	52.88	30.70	10.10	6.32	= 100

The oxygen is in the rest of these.

	SiO ₂	FeO	MgO	CaO
Stannern	26.90	7.03	4.14	2.18
Juvinas	28.20	6.82	4.04	1.81

or of $RO : SiO_2 = 1 : 1.88$ or $1 : 2.22$

This augite has entirely the composition of those from the Howardite of Svalbard or in the whole.

Eucrite of Petersburg. Lincoln Co Tennessee.

In this place only in contrast the whole is analyzed the quantity of both compounds therefore are only found by calculation

Anorthite			
SiO ₂	Al ₂ O ₃	CaO	Na ₂ O
12.90	11.05	5.28	0.83 = 30.06
42.91	36.76	17.56	2.77 = 100
Augite			
SiO ₂	FeO	MgO	CaO
36.31	20.41	8.13	8.73 = 68.58
52.94	29.76	11.86	5.44 = 100.

The Eucrite of Petersburg is thus entirely of the nature of the eucrite of Stannern and of Juvinas. Also the eucrite of Pongrac is plainly the same.

although Saugier preceded it only by an earlier analysis. Rammelsberg has found in the Eucrite of Juvenas 0.1% of Titanic acid and 0.25% of P_2O_5 . If by this means the presence of 0.25% of Titanite and 0.6% of apatite is justified must remain provisionally accepted.

The Eucrite belongs probably to the stone of the 5th of December 1868 in Franklin Co Ala. Its weight is 615 grammes. According to the description of Brush it has a porphyritic structure, a green earthy mass with black, green, dark green and white parts. The black mineral is distinguished as Chromite, the white fuses B.B. with difficulty to a transparent glass similar to the anorthite, the yellow green and gray fuses with difficulty on the edges; Brush is doubtful whether it could be Olivine or Bronzite. Extremely small quantities of meteoric iron and sulphide of iron. The density of the whole is 3.26 - 3.35 the mean 3.31

According to Brush about 26% is dissolved by HCl.
(should be called, decomposed) the bases in the acid solution are the same as in the undecomposed part, yet each one contains more lime whilst the magnesia is found in the latter.

It is again very much to be regretted, that the chemical examination of these stones (of mixer[†]) is incomplete, it only has reference to the composition of these stones (of mixer[†]) is incomplete, it only has reference to the composition of the mass which accordingly contains,

SiO₂ 51.33, Al₂O₃ 8.05 FeO 13.00 MgO 17.59 CaO 7.03
Na₂O 0.45 K₂O 0.22 FeS 0.63 Cr₂O₃, FeO 0.62 = 98.92

According to Brush the meteorite of Franklin Co resembles before any other, that of Petersburg, Tenn. it was therefore a eucrite and the silicate furnishes

Anorthite		The remainder = Augite			Oxygen
SiO ₂	9.43	SiO ₂	41.90 =	55.37	29.53
Al ₂ O ₃	8.05	FeO	13.00	17.18	3.82
CaO	3.85	MgO	17.59	23.25	9.30
Na ₂ O	0.45	CaO	3.10	4.20	1.20
K ₂ O	0.22				
	<u>22.00</u>		<u>75.67</u>	<u>100</u>	

The rest is therefore a bi-silicate, in which Ca: Fe: Mg nearly as 1:3:8 differing from the Augite of the eucrite quoted. This explanation is contrary to the statement, that the acid abstracts also FeO and MgO, the indecomposable part should also contain Al₂O₃. Is Olivine present? Whilst Brach on the one hand regards this meteorite as very similar to the eucrite of Petersburg, he ascribes it to the Howardite (Luotakaks etc) which consists of Olivine, Anorthite, and Augite. Further research is requisite

7. Olivine, Augite and Anorthite.
(Howardite)

A less numerous but interesting group of meteorites whose nature it is necessary to elucidate by

further examination, and in which nickeliferous iron and iron sulphide are not entirely wanting. The chief representative is in the stone which fell on the 16th of Dec 1813 in Finland, in the parish of Savitaipale at Suotolaks (or rather the contemporary series). N. Nordenskiöld described it; Berzelius examined it partially. G. Rose its mineralogical nature lately described in great detail, and finally Arppe has, in a special treatise, compiled our present knowledge and enlarged it by analytical examination.

The greenish yellow, white and black grains, are in a light-gray fine grained, ^{earthy} mass which is very soft. The greenish yellow, are Olivine.

The white grains were incorrectly called Leucite by Nordenskiöld. G. Rose is inclined to consider them Anorthite. The dark grains in ~~pr~~ brown powder, contain an intermixture of the white mineral, it appears from this of Augite.

Chromic iron, iron sulphide, even metallic iron is met with in small quantities. All these compounds occur in them. B.B. fuses to a dark glass.

A. Olivine

The greenish yellow grains separate in the separation from the principal mass. They have the appearance of Olivine and are infusible before the blowpipe. They have not been analyzed since but the mass of the stone which Berzelius examined was, in consequence of the analytical results, almost nothing but Olivine. Accordingly the powder was subjected to the action of the magnet, filings of it treated with aqua regia which gave 93.5 decomposed and 6.5% of undecomposed part and that of the first consists of

SiO ₂	37.41		19.95	} oxygen O Ratio
Al ₂ O ₃	0.27	0.12		
FeO	28.61	6.36		
MnO	0.79	0.17	19.82	
MgO	32.92	13.17		
	<u>100</u>			

This is exactly the composition of the Olivine
Chassigny (and of the Hyaloxiderites)

But is very striking that this is almost solely
from Olivine, and no doubt one very rich in
iron, constituting part of the stone of Suotakak
according to Berzelius, that it should be a transpar-
ent-white laminated or foliated mineral, in
which there can be nothing of the principal
mass. In this place an error evidently exists

B. The white mineral.

According to Arppe it is cleavable in two oblique
angled directions and in a vertical direction, but it
is not separated from the mass as much as from
the olivine, ~~that~~ has been examined. ~~by~~ Arppe, and
G. Rose are of the opinion that it bears resemblance
to anorthite.

C. The gray earthy mass

It was subjected to the action of the magnet
and separated from the greenish yellow grains of
Olivine and then gave

or after excluding $\text{SnO}_2(\text{H}_2\text{O})$ and 1.77% of $\text{FeO}, \text{Cr}_2\text{O}_3$					oxygen
		a			
$\text{SnO}_2(\text{H}_2\text{O})$	0.10				
SiO_2	48.57	$48.57 =$	49.50		26.40
Al_2O_3	11.61	11.61	11.82		5.53
Cr_2O_3	1.20	.....	.....	.....	
FeO	18.81	18.24	18.50	4.11	11.06
MgO	10.70	10.70	10.90	4.36	
CaO	8.43	8.43	8.59	2.45	
$\text{Na}_2\text{O} + \text{K}_2\text{O}$	0.58	0.58	0.68	0.14	
	<u>100.</u>	<u>98.13</u>	<u>100.</u>		

In this silicate the oxygen of the bases and the acids is therefore = 1:1.6 a second analysis of the earthy mass gave.

SiO_2	46.50				24.8
Al_2O_3	9.75				4.56
FeO	36.31	accordingly a =	22.84	57.08	12.70
MgO			13.47	57.39	
CaO	7.80			2.23	
	<u>100.36</u>				

Here that proportion is 1:1.44

The figures of b are derived from a research of Arppe the whole treated with HCl by which it gave, all the alumina and the greater part of the lime such as perhaps $\frac{1}{4}$ th of the iron, no magnesia however (accordingly the bulk of the mass contains no olivine) is this credible?) passes over in the acid solution. It is to be regretted, that Arppe has neglected to

determine the silicic acid which belongs to A. he gives it,

	A	B
SiO ₂	46.50	
Al ₂ O ₃	9.75	
FeO	5.97	
MgO	.....	
CaO	5.96	
		} 30.34
		1.84

It can be seen that

B in reality is a silicate of iron and magnesia. We assume that it is bronzite, then we have in A.

SiO ₂	34.72	18.52	} =	51.90
FeO	19.10	4.24		28.55
MgO	11.24	4.50		16.80
CaO	1.84	0.52		2.75
	<u>66.90</u>			<u>100.</u>

Remainder				
SiO ₂	11.78	6.28	} =	42.85
Al ₂ O ₃	9.75	4.56		35.47
CaO	5.96	1.70		21.68
FeO	5.98	1.327		<u>100</u>
	<u>33.46</u>			

The lime=magnesia silicate was anorthite and the iron admixed as metallic iron. = 4.64% (or perhaps as ~~Pyrrhotite~~ magnetic iron) This expression of the aggregate then

4.64 Fe
27.49 Anorthite
66.90 Bronzite

is not in contradiction to its properties and its entic behavior. The Augite was Mg SiO₃, Fe SiO₃

The brownish black powder grains they are according to Uppe contained in greater quantity in the main mass; give a gray powder and has a density of 3.11 It consists of

SiO ₂	47.53		oxygen.	25.35
Al ₂ O ₃	15.21			7.04
FeO	18.82	4.18	}	10.37
MgO	6.65	2.66		
CaO	12.36	3.53		
SnO ₂	0.80			
	101.37			

The ratio of oxygen is 1:1.46 thus approximately as in the bulk. The most daring assumption would be that these grains are of a nature similar to the mass. Excluding the alumina and calculate the Anorthite we obtain.

Anorthite	Rest -			oxygen
SiO ₂ 17.62	29.91	50.25		26.8
Al ₂ O ₃ 15.21	.....	.....	.....	
CaO 8.22	4.14	6.96	1.99	} 13.49
41.05	FeO 18.82	31.62	7.03	
	MgO 6.65	11.17	4.47	

This remainder corresponds so exactly to a bisilicate, that it could almost be considered a part of the stone as 41 anorthite + 59 augite,

This augite almost completely agrees with the the eucrite of it, in particular with that of

Stannern. Uppé's assumption that this remainder contains Augite and Olivine, is from its basileate nature ~~doubtful~~. admissible with the restriction that later researches may complete our knowledge of Howardite, the meteorite of Suolotaks might be a mixture of Olivine, Augite and Anorthite.

Moreover, to Howardite belongs the meteorite of Mässing, Zialystock, Northborough and perhaps also that of Franklin Co. Ala.) There is considerable probability of the existence of Olivine in it, yet in its chemical relations, it is literally unknown.

Concluding Remarks.

The elementary constituents of meteorites occur in minerals and no new element has ^{been} found in meteorites. Up to the present time all ~~researches~~ concur in this conclusion that meteorites are a mixture of different minerals, just as the terrestrial rocks, and it will be somewhat

311

minerals try to compare the cosmic minerals and rocks (meteoric) with the telluric minerals and rocks.

The minerals which occur in meteorites are

I Meteoric iron, or native iron, which contains some nickel. It is cleavable in three directions parallel to the surface of the rhombohedron, steel gray metallic lustre and is found compact and diffused, when compact, forms a particular division of meteorites, and as in Pallasite, diffused in many other meteorites, especially in Chondrite and mesosiderite.

II Tarnite

III Schreibersite

IV Khabdite. The three iron compounds which occur in meteoric irons for the most part ⁱⁿ regular concretions. It is of the color and glitter of nickeliferous iron and therefore by the entire circumstances of the case, it is not distinguishable from the latter, but is more difficultly

soluble than the meteoric iron and appears therefore upon its surface, if it has lain in such an acid for a time.

Tänite an iron richer in nickel than meteoric iron, it is found occurring in meteoric iron in octahedral fragments, in thin lamina, however which the octahedral surfaces are in parallel scales and by its appearance upon the etched surface section the Widmannstätten figures are especially brought out, as in the iron of Toluca, Elbogen etc.

The Schreibersite (Lamprite of Reichenbach) is a phosphide of nickel and iron, it is found in smooth ~~leaves~~ grains and in completely formed crystals, in the middle of the shells and these are parallel to one of the former varieties of meteoric iron, namely iron of Crosby, Arva, Senarto.

Rhabdite, is also a phosphide of iron and nickel, it is found in small, almost micros-

copical, four sided prisms which in three directions are parallel to the edges of the hexahedron and are regularly interpenetrated in the meteoric iron, namely Braunau, Seeläsen, Mestica. It is found in meteoric iron generally, only there where schreibersite is absent or when it occurs with this in the same stone as in that of Uva, yet only in the pieces which contain no schreibersite. The rhabdite present as well as the schreibersite consist of a phosphide of iron and nickel, then it is accordingly possible, one might say, probably that both are one and the same compound, but under different conditions.

V Graphite is intermingled in small portions of different sized grains, some as large as a walnut (Dolucka) sometimes as pseudomorphs in the form of small hexahedrons (Uva)

VI Troilite FeS By analysis is recognized as a mono-sulphide, it is found in more or less abun-

dance, usually limited portions in the meteoric iron, intermingled as the graphite yet more frequently than graphite (Toluca, Seeläsgen, Lockport). It is in part entirely without interspersions of nickelliferous iron as in the iron of Seeläsgen, in part it contains this in fine particles it also sometimes contains chemically combined sulphide of nickel (M of Suverbo).

Whether, in the mean time all sulphides of iron, which occur in meteoric iron, belong to troilite and not to the following magnetic pyrites, is yet undecided, as also, where the iron sulphide belongs which is found in small particles in Pallasite and Mesosiderite.

VIII Magnetic pyrites, pyrrhotine or ~~pyrrhotite~~ pyrrhotite is found in small crystals in the curite of Juvinas and according to Shepard in the Chondrite of Richmond. It is known by its form as magnetic and G. Rose thinks that

according to this it is probable that the iron sulphide in the above Eucrite and Chondrite, in which it always occurs interspersed in small lots, is magnetic pyrites; this is also probable, that much of the chondrite by solution in hydrochloric acid removes some sulphur. Nevertheless this could also occur with pyrrhotine or also in the state of troilite. From this uncertainty the above is provisionally assumed that all sulphides of iron in meteoric iron, pallasite and mesosiderite, Troilite and in the remaining meteorites; is pyrrhotine. Rammelsberg however makes the following remark,

Whether magnetic iron is a primitive formation in meteoric iron is to be doubted. Its meagre appearance favors the view of its secondary production

VIII Chromic iron earth. It is widely dif-

fused in meteorites, although always in small quantities. It is sometimes found crystallized in Octahedra, unusually in grains and interstratified; in unmistakably crystallized and in the largest grains, which sometimes reach the size of a small pea, in Shalkite, less rare and in smaller sized grains in the meteoric iron and in Pallasite, especially of Brahin, more finely interstratified in the Chassignite, Chondrite, Howardite. In meteoric iron it is often entirely interspersed in Troilite as in the meteorite of Carthago and Schwartz.

IX Quartz occurs in small almost microscopic crystals, yet measurable with the reflection goniometer, as in the meteoric iron of Toluca, but this is considered a great rarity. Quite recently Maskelyne has shown the occurrence of crystallized silica in the Bronzite - Pallas of Breitenbach which is perhaps Tridymite, but this still

remains undetermined

X Olivine $(Mg, Fe)_2 Si$ a frequent and important ingredient of meteorites. It occurs crystallized, in grains and also compact or massive.

In the distinguished crystals in Pallasite, Mesosiderite and Shalkite, in small grains in Chondrite and Howardite, dense and almost the entire mass of the stone constituting the Chassignite. In the pallasite the crystals are often interpenetrated, often entirely round, when they are found on opposite sides and have become disturbed during their formation.

generally single and showing even many smooth and shining surfaces. which in part are not in contact, partly cut on the edges. The crystals are often completely transparent, yellowish green and highly lustrous as glass metal they frequently contain tubular cavities which are parallel to each other and the principal

axis. Olivine of most meteorites is infusible before the blow pipe, it does not change, except perhaps grows darker in color, the olivine in Chassignite barely fuses, only with difficulty, in consequence of its great percentage of iron is a dark glass as the hyalosiderites, with which it also corresponds in its percentage of iron.

Olivine is the wide spread representative of the unsilicate group. The magnesia and iron of the meteorites belongs to the Olivine and Augite. Meteoric olivine shows all the changes of isomorphous composition of Fe_2SiO_4 and Mg_2SiO_4 .

XI Shepardite. $\text{Mg}_2\text{O} \cdot \text{Si}_3\text{O}_3$ a principal ingredient of Chladnite in which it occurs in interpenetrated, incompletely formed crystals from the size of half an inch and upwards.

white as snow and very friable, almost insoluble in HCl. It is found besides in Shalkite, however in much smaller grains, but is other

wise not observed with certainty

XII Augite is found in Eucrite and mesosiderite, in the first, of a dark brown color, granular, and crystallized in the cavities as in the eucrite of Juvinas in very plain crystals as it usually occurs in the Siderite and newer volcanic rocks. Of bases it contains principally protoxide of iron, then magnesia, and lime, its formula $(\text{FeO}, \text{MgO}, \text{CaO}) \text{SiO}_2$

In mesosiderite it is coarse grained, especially in that of Suria de Chaco and dark green.

Augitic matter enters partly in the tetrabasic form of Enstatite and Bronzite as MgSiO_3 with changing quantities of FeSiO_3 partly as proper bi- and uni-basic augite. *

XIII Anorthite $\text{CaSi} + \text{AlSi}$ is contained in the eucrite which is a fine granular mixture of Augite with it. It is snow white, in granular aggregations plainly cleavable and often distorted twin like structure. In the cavities of eucrite of

as it is crystallized out, still more vaguely and smaller than that of the augite occurring with it. yet it is probably contained in Howardite and Chladnite. The following are some of the minerals which have been observed, ^{but} not determined.

I. The nodules in Chondrite, which in the interior of the mass quite fibrous and of a yellowish gray to grayish black color. Nodules of both colors are rarely found in the same meteorite but sometimes both colors are in the same nodule then in part as such with a light kernel or pith with a darker cover or crust or sheath, partly such with a darker kernel with a lighter crust.

Their composition has not been completely ascertained, but appear to be chiefly a magnesia silicate, it is separated from olivine by difference of solubility, although these nodules are not completely insoluble, yet they are soluble with greater difficulty than the olivine.

II. The black matter which is found in the

Chondrites by means of the microscope.

III. The yellow tabular crystals, which occur in the eucrite of Juvenias, & have a resemblance to Titanite.

IV. The white grains in Howardite as also those which occur with shepardite in Chladnite.

V. A mineral in Chladnite which contains according to Shepard Sulphur and Chromium.

There is one element, ^{any constituent} in meteoric crons which is not found in such a union in any of the rocks or terrestrial minerals which have been studied up to the present time and this is the double phosphide of iron and nickel.

There are certain indications of another mineral whose nature has not been yet determined and that is the occurrence of Tin in some as yet undetermined combination with Chromium. it was discovered by Berzelius but who made no effort to unravel the mystery which surrounds it to the present day, but it is of rare occurrence and there have not been

opportunities offered to study its nature.

Chlorine has been found to enter into the composition of meteorites and for a long time was attributed to Telluric origin but Silliman's researches have now left no doubt of its meteoric character.

REVIEW OF THE ISOMORPHOUS COMPOSITION
OF
OLIVINE AND AUGITE IN METEORITES.

I. OLIVINE Fe_2SiO_4 , n, Mg_2SiO_4

$Fe\ Mg_8$ Pallas mass. Blansko. Kleinbunden

$Fe\ Mg_7$ Lodran

$Fe\ Mg_6$ Pullusk. Murcia. Tadjera

$Fe\ Mg_5$ Stavropol

$Fe\ Mg_4$ Bratin. Alacama, Chantonnay

Shurnusala, Dundum, Nash-

ville, Clesel Richmond

$Fe\ Mg_3$ Hainholz. Borkut. Linn Co. St Mesmin

Muddoor. Shergotty. Tourmines. Utrecht.

$Fe\ Mg_2$ Chassigny. Alais. Luotolaks. Bachmut

Mauerkirchen, Montjean. Pamallee. Skye.

$Fe_2\ Mg_3$ Shalka. Guernsey Co. Amans. Uden

$Fe\ Mg$ Chateau Renard. Rakova

$Fe^2\ Mg$ Ensisheim

new Zealand and
many other
terrestrial Olivines

Sherz and other
terrestrial Olivines

Canada.

Sasbach (Hypoc-
siderite)

II BRONZITE Fe.SiO_3 , n MgSiO_3 (Sometimes some Ca)

Fe Mg_{11}	Seiperville
Fe Mg_9	Marburg. M.
Fe Mg_8	Biesouffars
Fe Mg_6	Sherz. Ullenthal Steiermark
Fe Mg_5 Lodran, Bachmüt. Blansko. Paltus K	Greenland. Texas
Fe Mg_4 Brettenbach, Ensdorfheim, Chantonnay, Klein Norden, Montréjeau, Cesel Richmond. Stauropol	Styria
Fe Mg_3 Hainholz Shalka, Dorkut, Guernsey Co. Lwin Co. Parnallee, Skye. Tournieres, Uden. Ullacht	(Hypersthene)
Fe Mg_2 Manegaum, Chateau Renard, Danville, St Mesmin, Seres, Sher- gotty	
Fe Mg Luololaks. Tadjera n R. SiO_3 , Al_2O_3	(Fe_4Mg_5)
$\text{Al}_2\text{R}_{5-6}$ Chateau Renard. Nashville, Uden	(Hypersthene)
Al_2R_9 Hainholz Klein Norden St-Mesmin, Stauropol	(Hypersthene)

Al₂ R₁₂ Bachmüt Chantonay
 Ensisheim, Amans. Seres
 Fournies

Al₂ R₁₅ Blansko. Guernsey Co
 Mauerkirchen, Montrejean
 Aesel, Richmond. Utrecht.

Al₂ R₁₈ Borkut, Rakova, Lim Co. Mud-
 door Pullus K Shergotty
 Skye Padjera.

III Diopside $\text{Ca SiO}_3, \text{Mg SiO}_3$ Eusti

IV. Augit $\left\{ \begin{array}{l} m \text{ Ca SiO}_3 \\ n \text{ Mg SiO}_3 \\ \text{Fe SiO}_3 \end{array} \right\}$

Ca: (Mg, Fe) = 1:6; Ca: Mg = 1:2 Lucolates. Eucrite
 1:12; Ca: Mg = 1:8 Franklin Co.

Carbon in Meteoric Iron.

Boussingault has made a series of elaborate researches on the various forms of carbon occurring in meteoric iron, he says,

Graphite, carburetted iron (the carbon probably being derived from bituminous matters) has been found in native iron and in meteoric stones. His researches were originally undertaken in order to ascertain if, in iron of cosmical origin, the carbon was in the same state as in manufactured pig iron, and in steel, the state designated by metallurgists as "combined carbon" and of which perhaps the most-salient characteristic is its complete disappearance during the evolution of the hydrogen gas resulting from the action of an acid upon the metal. Combined Carbon cannot therefore be detected by the ordinary process of analysis of irons and steels: chlorination was effected by bichloride of mercury.

1. Meteoric Iron of Gaille. (Maritime Alps) - This

iron was in small fragments. After having treated it with a solution of potassa, then with ether, in order to eliminate the organic matters adhering to its surface, it was dried in a current of hydrogen at a dull red heat, 0.986 grms of chlorinated iron left a residue of black carbonaceous matter, very finely divided

Carbonaceous residue 0.0065 grms

After combustion and reduction 0.0050

Carbon burnt 0.0015

2. A fragment of Laille iron weighing 5 grms was chlorinated. Residue carbonaceous, dull black in color, extremely comminuted

Weight 0.0830 grms

After combustion and reduction 0.0270 "

Carbon disappeared 0.0060 "

After chlorination, the carbon was very voluminous, and burnt like tinder when heated at the extremity of the platinum boat in which

it was deposited. In experiments 192.; 5.986 grammes of iron gave.

Carbon 0.0075 gm
being for 1 gm. combined Carbon. 0.0012 "
This is the proportion in which it is found in certain pig irons

3. 1 Gramme of Baillet iron gave on analysis

Fe_2O_3 1.279 grms

NiO 0.124 "

4. From 1.2 gr. iron was obtained. NiO 0.151 grms

+g

Nickel 0.1188 "

1 gramme of meteoric iron yielded volumetrically

0.8973 gr. iron .

Iron 89.53

89.73

Nickel 9.76

9.90

Combined Carb. 0.12

0.12

Insol in acid. 0.59
100.00

0.25
100.00

Traces of sulphur were present, chromium uncertain and cobalt not sought for.

His results differ quite perceptibly from the analyses of the same iron by the Duke de Luynes and M. Rivet.

	Rivet		Duc. de. Luynes
Iron	92.3	92.7	87.6
Nickel	6.2	5.6	11.4
Chromium, Cobalt, Si.	.....	00.9	Cu
	98.5	99.2	99.0

Meteoric iron of Lenarto (Hungary) I. - 1.265 gr chlorinated by bichloride of mercury.

Weight of residue 0.004 grams

after combustion and reduction. 0.004

Carbon 0.000

A second experiment gave the same result. The residue obtained after chlorination was of a metallic gray color; heated in the air to caught fire with several bright sparks. The burnt matter took a brown color, which disappeared on reduction of the mass in a current of hydrogen. It was therefore probably particles of iron.

There is neither carbon nor graphite in the
Lenarto iron. The sample examined contained.

Iron 91.30

Nickel 8.58

Copper

Carbon 0.000

Sulphur 0.00

Insol. resd. 0.30

100.38

The Immediate Analysis of Meteoric Irons.

Stanislas Meunier excels in the analyses of minute bodies, his accuracy is unquestioned and as he has compiled his methods I quote them without abridgement, not that they are unrivalled by others, not ^{that} they cannot be improved upon but because they are trustworthy in essential respects.

He summarizes the existence, in extra-terrestrial bodies, of the following compounds.

1. The general mass which is formed by the union of several alloys in which iron and nickel are predominant and which we will designate under the name of *nickeliferous iron*. Among the substances comprised in this mass, the *kamacite*, the *taenite*, and the *plessite* will be especially mentioned.

2. The carburetted iron comprising the *campbellite* and the *chalybite*, recognizable by the carboniferous deposit which they give under the action of acids.

3. The sulphuretted iron, or *troilite*, which appears in nodules or veins.

4. The phosphide of iron and nickel or *Schreibersite*.

5. The *graphite*.

6. The external crust.
7. The stony particles, or crystals
8. The gases retained by occlusion (Graham)
9. Several compounds which are only met with exceptionally, as chromite and proto-chloride of iron. The last may even have a terrestrial origin. Meunier's results are, for the greatest number, the fixation of their chemical formulae,

I. Nickelliferous iron

The first problem to be solved is the separation of the different alloys which are mixed in the general mass of meteoric irons; but it is necessary first of all to prepare that general mass freed from other substances which have been named.

For this end, the iron being reduced to powder by means of a hard file, the metal is thrown into pure polish fused in a silver crucible.

Instantaneously the alkali hitherto limpid, becomes troubled by the presence of little grey flakes, which are the result of decomposition of troilite, schreibersite, stony matters etc and consist of oxide of iron.

When this decomposition of foreign substance is complete, the alkaline mass is cooled and treated by water. All the potash is carried away with the greatest part of oxide of iron.

The remainder of this oxide is easily dissolved by strong nitric acid, in which the iron becomes passive.

The metallic powder is then well washed and dried; it is exclusively formed of nickeliferous iron, containing however, in certain cases, a small proportion of carburetted iron. Chemical methods have not yet completely succeeded in separating the alloys mixed in the nickeliferous iron, and, after several

essays, Meunier has been obliged to employ a physical process. His experiments have been made with the meteoric irons of Leuille (France) and of Charcas (Mexico)

First of all, it was necessary to determine with exactness the number of constituent compounds contained in the nickelliferous iron of those masses. For that purpose a small polished plate of the iron of Leuille was heated with precaution and uniformity. This operation of which the first idea is due to Widmannstätten, drew, by the unequal oxidability of the different immediate principles, a yellow net upon a blue ground. There were also several portions of an intermediate color, clearly limited like the others, and occupying the spaces, bounded by the crossing of the yellow lines.

An attentive examination showed that the three metals were reduced to two; the third

being formed by the mixture of the others, reduced to alternate thin sheets. The blue iron is formed by the kamacite and the yellow by the taenite. Their separation was very difficult on account of the analogy of the chemical properties of the two metals. If it is true that the kamacite is more soluble than the taenite (and this is proved by the experiment of Widmanstätten), it is true also that the difference is too small to permit a separation. When all the kamacite is dissolved, only a very small proportion of the taenite remains; the greatest part being dissolved also.

To effect the separation, Meunier heated some metallic powder placed upon a glass plate. The particles formed by kamacite become blue, whilst the particles of taenite are yellow. Then the two sorts of grains are separated with a pincer.

After about fifteen operations Meunier collected 2 grammes of kamacite, and 0.5 grammes of taenite that he could chemically examine.

The Charcas iron gives the same results. The specific weight of taenite is 7.38. Its analysis has given me the following numbers:—

Iron 85.0

Nickel $\frac{14.0}{99.0}$

which agree with the formula $\text{Fe}_6 \text{Ni}$

The kamacite has a specific weight equal to 7.652 and I have found for its composition—

Iron 91.9

Nickel $\frac{7.0}{98.9}$

Its formula is $\text{Fe}_{14} \text{Ni}$. On this subject it will be remarked that in admitting according to the numbers given ~~below~~ above, that the Laille iron contains 80 per cent of kamacite and 20 per cent of taenite, its elementary formula will be expressed by

$Fe_6 Ni + 4(Fe_{14} Ni) = Fe_{62} Ni_5$ which gives numbers very near those which M. Rivot has obtained in the elementary analysis of that mass. The above formula gives -

Iron 91.4

Nickel $\frac{8.6}{100.0}$

And M. Rivot has found, in two analyses -

Iron 92.3 92.7

Nickel $\frac{6.3}{98.6}$ $\frac{5.6}{98.3}$

All meteoric irons are not so simple as those of Bailly and of Charcas. There are some which contain with kamacite and taenite a certain quantity of other metallic alloys.

One of the most important of these is the plessite, which abounds, for example, in irons of Jewell Hill (Vt.) and of Oldham Ky.

Meunier isolated it by the same method which had served for the preceding substances.

The plessite offers a density of 7.850 and he thinks its composition is well represented by the formula $Fe_{10}Ni$, but he had so little of the substance that he could not make a satisfactory analysis. Amongst the other alloys of iron and nickel, Meunier gives the name of octubbe-hite, whose composition is exceedingly remarkable for the large portion of nickel (59.60%). Its density is only equal to 6.854. The meteoric iron of Octubbe-hite, seems to be entirely formed of that alloy; this results from the studies of Mr. Doyton.

II. Carburetted Iron.

Several meteoric irons give, by the action of acid, a black deposit more or less abundant, consisting of carbon. This carbon comes from a compound of which the composition is analogous to that of steel.

In this point of view, the meteoric iron of Campbell Tenn. will be specially mentioned. It gives by analy-

carb-

sis a metallic matter, formed by the union of 1.5% of carbon with 97.54 % of iron. He proposes for it the name of Campbellite; its density is 7.05

Mr Shepard gives the name of Chalybite to a carbide of iron of which Forchhammer has noticed the presence of it in the meteoric iron of Niakornak (Greenland) and of which the formula is CFe_2

~~I have had~~ III. Sulphuretted Iron.

To prepare the sulphuretted iron or troilite, in a complete state of purity, we may have recourse to the metallic powder. This powder is placed during a quarter of an hour in a boiling concentrated solution of sulphate of copper. All the nickeliferous iron is dissolved, and by decanting and washing, a mixture of metallic copper, troilite, schreibersite (which are magnetic) from graphite and stony matter. Lixivation in concusion, can be employed to isolate troilite from schreibersite. When the iron under experiment contains only a small quantity of troilite, it is

preferable not to make use of nitric acid, which always dissolves a little of the desired substance. In these cases the nickelliferous iron is dissolved by means of bichloride of mercury. The proto-chloride of mercury is carried off by a solution of chlorine, and it is easy to separate the metallic mercury.

Besides, it is always better, when possible, not to ^{to} exact troilite, from no matter what part of iron, but from the cylindroid nodules in which the substance has concentrated itself. Thus the sulphuretted iron contains only some graphite and stony matter, which can be got rid of by the action of the magnet.

It is correct to say that this troilite is one of the most characteristic principles of meteoric iron. Notwithstanding its crystalline forms have not yet been recognized, and there is some doubt about its chemical composition.

The first chemists who examined it considered it as a variety of Breithaupt's pyrrhotine, and gave

377

to it the formula Fe_7S_8 . But J. Lawrence Smith concluded from his analysis of the sulphur of the iron of Dazeuill, that it has the composition of the proto-sulphide FeS . Notwithstanding, he continued to give it the name of pyrrhotine, and thus a great confusion was introduced into the nomenclature. Besides, Mr Smith rested both upon the results of his own experiments and upon those obtained by several chemists in the examination of other troilites, his conclusion was not admitted, and the existence of true crystalline magnetic pyrites in meteorites will increase the doubts.

The distinction between the troilite (or Mr Smith's pyrrhotine) and the Breithaupt's pyrrhotine is not so clear as it seems at the first view, the difference of composition is very slight, and the physical properties are very similar. Meunier thinks the mineral in question nearer to magnetic pyrites than to proto-sulphide of iron.

35
J. Lawrence Smith has treated the graphite of the
Cranbourne Meteorite with strong nitric acid and found

to contain	Sulphur	35.05-	} Troilite
	Iron	62.21	
	Cobalt-	0.56	
	Nickel	0.16	
	Magnesia	0.30	
	Silica	0.21	
		<hr/> 98.62	

He calls this combination troilite and remarks that
in these nodular sulphide of iron accretions the
quantity of nickel and cobalt is exceedingly minute.
He has also noticed that in these nodules the cobalt
is apt to predominate over the nickel, this can not
however be stated to be the rule because the number
of determinations of troilite is very small and the
result above given may not be applicable to all meteoric
iron; we have no doubt however that further research
will confirm Sir Smith's conclusions.

Meunier believes protosulphide of iron can be
distinguished from magnetic pyrites and from
compounds richer in sulphur in the following
manner.

When proto-sulphide of iron is placed in a
solution of copper, it precipitates this metal

almost like iron itself; pyrrhotine, on the contrary does not produce such a precipitation, the protosulphide obtained by the action of sulphide of ammonium upon iron salts produced the same effect as the substance of exactly the same composition prepared by igneous means. This being well established, Meunier put several troilites into a solution of copper, and he did not observe any precipitation. The ~~protosulphide~~ troilite is then like the magnetic pyrites in this respect, and we may arrive at the same conclusion relatively to the chemical composition. Mr Smith has based his formula FeS , upon his analysis of Dazeur's troilite, which gave him:—

Iron	62.38
Nickel	0.62
Copper	.....
Lime	0.08
Silica	0.56
Sulphur	35.67
	<u>99.31</u>

Meunier thinks these numbers show that the substance employed in his experiments was very impure. Meunier purified the troilite by the process described above and obtained a matter of which the density was 4.799. Its color was bronze, and

its analysis yielded

Iron	59.01
Nickel	0.14
Cu	...
S	40.03
	<hr/> 99.18

the formula Fe_7S_8 requires Iron 60.4 + Sulfur 39.6%

The Charcas troilite previously purified gave

Fe.	56.29
Ni	3.10
S	39.21
	<hr/> 98.60

Its density is equal to 4.78

The normal presence of ~~troilite~~ nickel makes of troilite a species distinct from pyrrhotine and its true formula is $(\text{Fe. Ni})_7\text{S}_8$

IV Schreibersite

Meunier prepares schreibersite, or phosphide of iron and nickel by the same method as troilite. Besides, as for the latter, it is always preferable to take the schreibersite in the places where it is naturally concentrated. It is a metallic matter yellowish or almost white. Its specific gravity is 7.103 and Meunier has found in the schreibersite of Toluca iron:—

Iron	57.11
Nickel	28.33
Cobalt	.....
Mg	.....
Phosphorus	15.01
	<hr/> 100.47

these numbers lead to the formula $\text{Fe}_4 \text{Ni}_2 \text{P}$ yet admitted by Mr Smith after the analysis of the Tazewell's schreibersite. Bergemann analyzing the same but impure substance found,

Iron.	87.0
Nickel	9.5
Phosphorus	3.5
	<u>100.00</u>

Schreibersite is magnetic, and takes permanent polarity by contact with a magnet. It is brittle. Hydrochloric acid has not any reaction upon it. Crystalline forms have not as yet been observed.

V Graphite

Action of fuming nitric acid (Nordhäuser acid) mixed with potassic chlorate on the meteoric graphite. The oxidation of graphite by this method is well known to chemists, it having been first pointed out by Mr Brodie in 1860 and subsequently by Berthetot. Berthetot's method is as follows To free the powdered graphite from sulphide of iron by first treating it with strong nitric acid, washing it thoroughly on a filter, drying it and mixing it with five times its weight of potassic chlorate, then adding this mixture little by

little to sufficient fuming nitric acid to thoroughly moisten the mass. In making this mixture place the nitric acid in a capsule and the latter in a little water with a piece of ice, thus avoiding any risk of explosion. The mixture, after standing a few hours is transferred to a ballow d'assais, and gently heated in a water bath at a temperature from 50° to 60° C for several days.

Meunier's method is as follows: -

- A few grammes of metallic powder are projected into fused potash, and thus a mixture of mickelliferous iron and graphite is obtained. This mixture may be treated in several ways.

Ist. Iron is dissolved in hydrochloric acid, which leaves as residue the graphite almost pure.

IInd. The graphite is separated by lixiviation. This process presents the advantage of giving both graphite and mickelliferous iron; but the separation is never complete.

IIIrd, and lastly. The magnet may be employed only when the graphite is abundant; in other cases it is drawn up with the metal.

In all cases the residue is washed by hydrochloric acid to dissolve foreign matters, such as troilite and schreibersite, or what results from their being attacked by fused alkali. The graphite extracted from the caills iron shows a density equal to 1.715. Its analyses afforded

Meunier Carbon. 97.3

Iron	2.4
Nickel	.....
	<hr/>
	99.7

The graphite of the Charcas iron has a density of 1.309, and the result obtained by Meunier is,

Carbon 98.0 Iron 0.9 = 98.9. The graphite is remarkable on account of its great unalterability. J. Lawrence Smith's researches on solid carbon compounds are exceedingly interesting and thorough and regret the lack of time and space to do justice to his excellent work. He says:— The graphite nodules as well as all the nodular concretions in nucleonic irons are grand chemical and physical puzzles. and in regard to the graphite concretions he is inclined to adopt Berthelot's suggestion, viz, that they may be formed by the reaction of bisulphide of carbon upon incandescent iron, as this reaction is known to give rise to an amorphous graphite analo-

gous to the one under consideration, its association with sulphide of iron, the presence of free sulphur and a carbon compound, either a hydrocarbon, or sulph-hydrocarbon, lends some support to this hypothesis.

It is very evident from the present accumulated knowledge of the geological occurrences of graphite that we must abandon all attempt to account for its formation by any one series of reactions on the interior of our globe; for it is to be found in basaltic rocks, in the older crystalline rocks, and through all the series of rocks up to the Tertiary formations, and the elaborate researches of Berthelot shew that this view. So far then as our present knowledge goes we know of celestial carbon in three conditions viz: in the gaseous form as detected by the spectroscope in the attenuated matter of comets, in meteorites in the solid form, impalpable in its nature and diffused in small quantities through pulverulent masses of mineral matter that come to the earth from celestial regions; also in the solid form but compact and hard resembling terrestrial graphite, and this is imbedded in metallic matter that comes from regions

in space.

VI. External Crust.

The portions of meteoric iron, upon which is the crust, being separated by means of a saw, they are placed in a concentrated solution of bichloride of mercury. After a sufficient time all metallic particles are dissolved, and the oxides, ~~are~~ amongst which is the crust, remain alone.

However, the crust is still mixed with foreign matters. Usually there is with it the products of its alteration by atmospheric agents, and particularly limonite. Some schreibersite, troilite, and stony grains may be also mixed with the principal substance, and their separation is very difficult.

Weak hydrochloric acid carries away limonite and troilite; stony grains remain as residue after the action of the magnet; lixiviation permits the purification of the crust from schreibersite. Besides these operations may be simplified by choosing the portions of the crust that seem almost pure. They frequently detach themselves from the subjacent metallic matter. Very few chemists have analyzed the external crust of meteoric irons. The analyses given by

Pugh, as showing the composition of the crust of the Toluca iron, have evidently been executed on an impure mineral. Pugh's results are.

	<u>Pugh</u>	<u>Meunier</u>
Fe.	18.717	
FeO	19.309	28.12
Fe ₂ O ₃	32.750	6.893
NiO	5.751	NiO. 2.000
CaCO ₃	.....	CoO
Silicates	10.203	99.05
Water	13.270	
Chlorine	.....	
	100.0000	

Meunier remarks, evidently metallic iron, silicates, and water

are not essential elements of the crust and must be considered as impurities, after purifying the Toluca iron crust, he found its density to be 4.89 and its composition as given above; his numbers agree with the formula Fe_{20}O_3 , $(\text{Fe Ni})\text{O}$, which does not differ from that of magnetite except by the substitution of a small portion of nickel for a corresponding quantity of the iron of the protoxide. It is remarkable that if in Pugh's analysis we only consider sesquioxide of iron, protoxide of iron, and protoxide of nickel, and of cobalt, we arrive at numbers very near to those required by the above formula.

Haidinger offers some very curious and interesting speculations about the enamelled crust of

meteoric stones, based upon Dautree's, his own, and others' researches, for which I have not space to compare and discuss, it is to be regretted that Meunier has neglected to compare his results with theirs.

VII. Stony Grains.

Iron in form of lumps is left-protected from the contact of the air in a concentrated solution of bichloride of mercury, and frequently stirred.

After a sufficient time the metal disappears, and the liquid ~~and~~ contains stony grains mixed with protochloride of mercury, and generally with a small quantity of metallic mercury. There is also troilite, schreibersite, and graphite. A solution of chlorine chlorine carries off the calomel and the magnet isolates the schreibersite and the troilite, lixiviation may be employed to get rid of graphite. In certain cases time can be saved by submitting to the action of a current of hydrogen the magma produced by the action of the bichloride. Heat carries off the calomel, the mercury, the troilite and the schreibersite. The stony matter is purified from graphite by lixiviation. If the grains are unoxidizable hydrogen can be replaced by air.

These grains are of different composition, and it appears that there exists a certain relation between their composition and their situation. Some are localized in the iron; others are situated in the troilite, or, perhaps in the graphite which surrounds this sulphur. The grains of the first category may be found in the iron of Dazeuill and of Tucson. They are formed of peridotite as proved by Smith. Meunier finds the density of these grains to be 3.35. He has not observed crystalline forms. The grains of the second category are given by the troilite of the Cailla iron. Their quantity was too small for analysis, but have been submitted to a blow-pipe assay. They are infusible and afford a reaction for silica. The troilite of Chacras affords analogous results.

VIII. Gases.

Gases in meteoric iron have been studied by Boussingault and Graham and are now being investigated by Abright, Mallet and others. I have particularized Graham's researches in another place.

IX. Rare Substances.

Chronite and protochloride of iron, their separation is not difficult and their composition is iden-

tical with that of analogous terrestrial compounds. Meunier remarks that the methods, which have permitted him to separate in a state of complete purity the immediate principles of meteoric iron, can be employed to estimate the relative quantity of the substances in question. He has submitted to a quantitative immediate analysis the meteoric iron of Tiquipilco, discovered in 1784 in the valley of Toluca (Mexico) and found in it

Nickelliferous iron	96.801
Graphite	1.176
Troilite	1.482
Schreibersite	1.232
	<u>100.691</u>

These numbers are exact exclusively for the analysed specimen. In other parts of the same mass, crust stony matters etc. may be found, and perhaps some of the above named principles can disappear.

TABLE I

Siderites - Complete Analyses.

	SiO ₂	FeO	Al ₂ O ₃	MgO	CaO	Na ₂ O	K ₂ O	MnO	S	P	Cr	Ni	Co	Cu	Zn	C	Fe ₂ O ₄	Insol
Alais	21	40.00		9				2	3.5		1	2.5				2.5		
Com. Inst. de France.	30	38.00		11				2			2	2				2.5		
Bergeluis	31.22	29.03	2.36	22.21	0.32			0.26									0.63	
Alessandria	37.40	19.37	8.65	11.17	63.14				3.831		0.845	1.077					(Fe ₂ O ₃) 12.834	1.673
Auesum	64.35	16.80		12.70	0.55	1.60			2.00								(Fe ₂ O ₃) 2.00	
Filhol & Symore	38.83	38.23		24.65	1.29												(Fe ₂ O ₃) 2.65	
do	61.58	16.90	2.00	11.80	0.60	2.30		2.00										
do	42.00	19.65	2.46	27.39	1.23	0.20	0.33	2.09			(+O ₂) 0.83			0.26			(Fe) 2.74	
Harris																	(Fe) 84.71	
do												12.11	0.72					
Bachmüt																		
Kuhleburg	40.20	22.37	2.88	20.11	0.06	0.51		0.03	2.51	0.04		1.19	5	8.10			(Fe) 0.64	0.22
do	38.97	15.23	2.55	26.62		0.73		0.04	2.22	0.05		1.29	3	8.92			(Fe) 0.93	0.18
Reichenbach	44	21	3.00	18.00							1	2.5						(Fe) 1
Wöhler	33.71	14.77	2.78	27.33	1.24	0.45	0.13	1.03	1.81	0.02		1.09		42.00			2.00	1.
Vaandersen	17.25	16.87	1.43	12.81	0.30	0.70	0.89	0.12	2.13			1.03	0.14	4.95			(Fe) 0.31	
do. 39.88%	20.40	2.53	0.43	0.76	1.49	0.18			3.80			6.32		4.30			(Fe ₂ O ₃) 4.41	

	SiO ₂	FeO	Al ₂ O ₃	MgO	CaO	Na ₂ O	K ₂ O	S	P	Fe	Ni	Co	Mn	Cr	H ₂ O	in acid
Barbotan Vauquelin	46		15	2						(+0.03) 38	2.5	1				
Bencares Vauquelin	48		13							(+0.03) 38	(3 Mo) 0.3					
Bishopville Shepard	70.71		28.25	1.39						(+0.03) 1.25			(+0) 0.20			0.80
Rammelsberg	57.52		2.72	34.8	0.66	1.14	0.70									
Wallerhausen	67.14		1.48	27.11	1.82					(+0.03) 1.70				0.67		
do	68.35		1.50	27.60	1.85									0.68		(C) 2.25
Blanco Berzelius	21.31		1.21	17.06	0.18					19.51	0.88		0.12	0.17		
Bergo. San Domingo. Fuidoué	50.0	28.00	19.0							(+0) 2.5	1.00					
Bort									4.19	0.18	85.14	10.06			0.4	
Curisany																
51.54% do	n.m.s	30.77	2.62	30.93	1.02	1.08	0.43	0.3		27.29			1.51			(Fe ₂ O ₃) 1.66
48.46% do	n.m.i	56.37	11.89	17.39	3.84	3.66	1.12				4.13					
Emmerwäde Wöhler	45.4	436	2.34	22.4		1.18	0.07			21.61	1.89					(Fe ₂ O ₃) 0.14
Cabaras Co Shepard	52.168	18.108	1.797	10.406	...		3.394									
Lehmannmay Berzelius	i	56.25	7.25	6.025	20.396	3.106	1.00	0.512								
51.12% do	s	32.607	28.801	34.337			0.977			(+0) 0.456			(+0) 0.821			0.69
Leharkow Schnauert		48.00		22.05						21.78	1.60		(+0) 6.00			
Giese										(+0) 4.20						3.00
Scheerer		51.00		20.25						19.8	1.5					

	SiO ₂	FeO	Al ₂ O ₃	MgO	CaO	Na ₂ O	K ₂ O	Cr	Mn	S	Fe	Ni	FeCrO ₄	C	P	H ₂ O
Charsonville	38.4	3.6	13.6	4.2				1.5	0.6	5	25.8	6	3.77			
Chassigny	35.3	26.7	34.76			0.66		+0.3 0.75	+0							
Vauquelin	33.9	31.0	32.0					2.00								
Lucien Renaud. Dufresnoy	38.13	29.44	3.82	17.67	0.14	0.86	0.27		...	0.39	7.7	1.55				
Gold-Bokkeweld Faraday	28.9	33.22	5.22	19.2	1.64	...		+0.3 0.7				+0 0.82				
Harries	30.80	29.94	2.05	22.2	1.70	1.23		+0 0.76	+0 0.97	338	2.50	1.30		0.03	1.57	...
Concord	51.25	25.20	45.825	8.873				...		1.184	8.803	2.36				0.035
Madelung	40.391	18.133	2.3	23.51	2.523						5.778	0.235	(NiO) 0.812	(Fe ₂ O ₃) 5.819		
Shepard	84.973			12.076				(NiO) 2.718								
Smith	47.30	28.03	0.31	24.53	0.02	1.04										
do																
Blaywater w.c. Smith	st pt 44.98	(+al) 21.95		29.30	1.80	1.32				1.08	87.011	12.36	0.42			0.12
Leynthiana Ky Smith	1	57.6	11.42	0.43	23.97	5.70										0.38
S	83.65	30.83	0.11	34.61	...	1.24		+0 0.38								
Dacca																
Stein																
89.25% do	n.m	36.39	27.41	2.91	26.32	1.29	2.37			3.80	81.86	12.87	(Cu) 0.84			0.42
Danville Ala. Smith	S	50.08	19.85	4.11	20.14	3.90				0.34		+0 0.98				
45.90% do	i	45.90	23.64	1.73	26.52	2.31	0.51		...	1.01						...

	S	i	s	Cr	Mn S	Fe	Ni Fe ₂ O ₄ Cl Loss P CO ₂
Durresula Haughlone	39.75	63.56	39.75	0.29	38.47	0.10	0.02
do	18.4	24.19	0.62				
Jackson	40.00	27.7	0.4	26.6		0.8	0.049
Eichstadt Klebroth	37		21.5			19	1.5-16.5
Weisheim Barthold	42		14	2		20	4.50
Fourcroy Vauquelin	58	30	12	1.4		(+0)	2.4
Epinal Vauquelin	35-		4.25	(+K ₂ O) 1.25-		22	(+0) 0.5-0.87
Cordorn Klebroth	39.5		1.25	26.5		31	(+S) 3.75-
Shmeyer	36.3	-5.57	41.605	23.584	1922	0.741	0.358
Forcyth Shepard	50.0	33.33	1.80	9.30	5.30		
Franklin Co. Ala. Mixer	57.33	13.7	8.05	17.59	7.03	0.45	0.22
Harrison Co. Smith	47.00	26.05	2.35	27.61	0.81	0.42	0.68
Heredia Dorneyko	33.6	36.9	35.1	0.1			
Lindstrom	36.83	12.85	2.38	23.21	1.80	0.94	(Na) 0.94
Nordenstjöld	36.75	13.36	2.00	26.06	1.50	1.03	(Li) 1.03
	37.08	13.49	1.11	24.06	2.66	2.11	

St. Etienne Kuhlberg

Albion Lath

Longac
Pudrias
Langier

36.77% Rammelberg

68.28%

do

Vauquelin

Kaba

Wöhler

Kakora

Harris 56.7%

" 43.3%

Killeber

Haughton 34.8%

" 30.42%

Kernow

Pisani

Klein Vanden Rammelberg

" 5-17.45%

SiO₂ FeO Al₂O₃ MgO CaO Na₂O K₂O Cr Mn S Fe Ni Fe₂O₃ Cu P₂O₅ FeCrO₄ TiO₂

39.66 19.15 1.06 26.12 139 0.

46 1.6 7.5

40 10.4 0.8 9.2

44.38 33.73 0.36 18.07 1.03 0.83

52.07 30.81 0.24 9.98 5.68 0.41

40 13.4 8 11.6

34.24 26.20 5.38 22.39 0.66

19.5 24.4 11.2 0.7

2.46 15.8 0.8 1.92 0.26

58.01 12.18 5.35 24.03 3.41

32.95 11.70 3.19 23.68 1.89 1.41

31.206 37.38 1.674

51.009 11.063 9.077 22.072 4.795 1.629

(+0)

0.28

(+0.3)

1

(+0.3)

2.8

(+mm)

27

(+0)

1.5

(+0)

6.5

(+0)

0.5

(+0.3)

1

(+0.3)

0.2

(+0.3)

0.83

(+0.3)

0.41

(+0.3)

11.6

(+0.3)

0.66

(+0.3)

11.2

(+0.3)

2.46

(+0.3)

58.01

(+0.3)

3.19

(+0.3)

37.38

(+0.3)

1.674

(+0.3)

22.072

(+0.3)

4.795

(+0.3)

1.629

(+0.3)

0.83

(+0.3)

0.41

(+0.3)

11.6

(+0.3)

0.66

(+0.3)

11.2

(+0.3)

2.46

(+0.3)

58.01

(+0.3)

3.19

(+0.3)

37.38

(+0.3)

1.674

(+0.3)

22.072

(+0.3)

4.795

(+0.3)

1.629

(+0.3)

0.83

(+0.3)

0.41

(+0.3)

11.6

(+0.3)

0.66

(+0.3)

11.2

(+0.3)

2.46

(+0.3)

58.01

(+0.3)

3.19

(+0.3)

37.38

(+0.3)

1.674

(+0.3)

22.072

(+0.3)

4.795

(+0.3)

1.629

(+0.3)

0.83

(+0.3)

0.41

(+0.3)

11.6

(+0.3)

0.66

(+0.3)

11.2

(+0.3)

2.46

(+0.3)

58.01

(+0.3)

3.19

(+0.3)

37.38

(+0.3)

1.674

(+0.3)

22.072

(+0.3)

4.795

(+0.3)

1.629

(+0.3)

0.83

(+0.3)

0.41

(+0.3)

11.6

(+0.3)

0.66

(+0.3)

11.2

(+0.3)

2.46

(+0.3)

58.01

(+0.3)

3.19

(+0.3)

37.38

(+0.3)

1.674

(+0.3)

22.072

(+0.3)

4.795

(+0.3)

1.629

(+0.3)

0.83

(+0.3)

0.41

(+0.3)

11.6

(+0.3)

0.66

(+0.3)

11.2

(+0.3)

2.46

(+0.3)

58.01

(+0.3)

3.19

(+0.3)

37.38

(+0.3)

1.674

(+0.3)

22.072

(+0.3)

4.795

(+0.3)

1.629

(+0.3)

0.83

(+0.3)

0.41

(+0.3)

11.6

(+0.3)

0.66

(+0.3)

11.2

(+0.3)

2.46

(+0.3)

58.01

(+0.3)

3.19

(+0.3)

37.38

(+0.3)

1.674

(+0.3)

22.072

(+0.3)

4.795

(+0.3)

1.629

(+0.3)

0.83

(+0.3)

0.41

(+0.3)

11.6

(+0.3)

0.66

(+0.3)

11.2

(+0.3)

2.46

(+0.3)

58.01

(+0.3)

3.19

(+0.3)

37.38

(+0.3)

1.674

(+0.3)

22.072

(+0.3)

4.795

(+0.3)

1.629

(+0.3)

0.83

(+0.3)

0.41

(+0.3)

11.6

(+0.3)

0.66

(+0.3)

11.2

(+0.3)

2.46

(+0.3)

58.01

(+0.3)

3.19

(+0.3)

37.38

(+0.3)

1.674

(+0.3)

22.072

(+0.3)

4.795

(+0.3)

1.629

(+0.3)

0.83

(+0.3)

0.41

(+0.3)

11.6

(+0.3)

0.66

(+0.3)

11.2

(+0.3)

2.46

(+0.3)

58.01

(+0.3)

3.19

(+0.3)

37.38

(+0.3)

1.674

(+0.3)

22.072

(+0.3)

4.795

(+0.3)

1.629

(+0.3)

0.83

(+0.3)

0.41

(+0.3)

11.6

(+0.3)

0.66

(+0.3)

11.2

(+0.3)

2.46

[illegible]

Locality	SiO ₂	FeO	Al ₂ O ₃	MgO	CaO	Na ₂ O	K ₂ O	S	Fe	Ni	MnO	P	Fe ₂ O ₃	Co	Fe ₂ O ₃ Cl	H ₂ O	Total
Mauerpickens Inlet	25.4				28.75				2.53	1.2			40.24			(+8)	2.08
Memo Smith		(40.20)							91.86	7.53				0.13			36.5
do	44.70	22.26		28.97	1.85	1.20											
Meghadadas. Withers	51.84		5.68	87.46	1.70	3.44	0.30										
Attinson	60.70	15.25	1.85	15.49	3.05	1.91	1.13		(FeS) 3.13	(+S) 6.79	(+O) 0.07		(FeO) 20.08			graphite 0.82	
Nilena Mendtovich	46.40		9.02	26.27					(FeS) 20.52	13.63	1.36						0.92
Murcia (1858) Meunier	29.22	5.23	0.51	27.93	0.09	0.35											
Sanjenny Chilton	um 89.6		0.2	1.04	7.8			5.08					24.6				
Kash Co. W.C. Smith	38.01	17.51	0.46	41.27													
"	52.61	13.21	4.80	27.31	1.38												
New Concord vide Concord																	
Art. Kuhlberg	40.00	16.98	3.52	25.59	0.05	0.65	0.08	2.02	8.36	1.82	0.03	0.05	(mm)				
Nottingham Webster	29.6		4.7	24.8				18.3	14.9	2.3				(CuO) 4			
Ohaba Buckheiser	36.60		0.28	23.45		0.98		(FeS) 13.14	21.40	1.80	0.15					0.56	NH ₃
Orqueil	24.47	17.92	4.17	5	8.163	2.183	1.244	0.307	4.369	Hummer (40)	1.815		13.324	0.85	0.225	0.073	734 (found)
" at 110°	26.03	19.06	1.25	8.67	2.32	1.32	0.32	46.4	"	(40)	1.93		14.23	0.09	0.24	0.07	781 (found)

	SiO ₂	FeO	Al ₂ O ₃	MgO	CaO	Na ₂ O	K ₂ O	Gr ₂ O ₃	Fe	FeO	MnO	S	Cl	Fe ₂ O ₃	P	Ca	Al	E	H
Orqueil																			
Pisani (1110)	26.08	21.60	0.90	17.00	1.85	2.28	0.19	0.49			2.26	0.36	1.52	0.08	8.30	...	...	...	...
do	Smith	...	...	0.30	0.16	0.77	0.16		4.12	1.85 (+0)	2.88	...	1.40	0.18	...	...	...	...	...
Orqueil	31.23	24.71	4.32	24.40	2.27	0.55						2.69							
L. Lippöcz	36.82	9.41	2.31	21.69	2.31	0.96	0.26	...	22.11	3.04		2.04							
	38.01	6.55	2.22	24.11	2.33	1.46	0.31	...	22.34	2.13		1.94							
Orifak (vinsk)						ua	K		93.24	6.56		1.21							
Nauckhoff	st. pt.	42.72	14.27	16.01	7.93	10.10	1.65	0.13	4.57	0.44		0.32							
"	iron scales	0.26		1.45	0.33	0.55	0.09		58.25	0.30		0.16							
"	i	75.67		2.92	3.16	3.15													
"	Granstone with Fe	36.59	14.85	19.18	7.24	8.73	0.79		5.01	0.25	0.29								
Nordenskiöld		...	...	0.04	...	...	...		84.49	2.48		1.52							
Nordstrom		0.66	0.24	0.29	0.48	0.14	0.57		86.34	0.35		0.22							
Wöhler									80.64	1.19		2.82							
Pelestung		49.21	20.41	11.05	8.13	9.01	0.83		0.50	...	0.04	0.06							
Pohly		38.009	4.896	3.468	29.93			0.13	17.849	1.365		1.146	2.695						

	SiO ₂	FeO	Al ₂ O ₃	MgO	CaO	K ₂ O	Na ₂ O	Fe ₂ O ₃	Fe	Co	Ni	S	P	FeCO ₃	MnO
Pellusck															
"	46.17	15.25	1.2	29.53	0.31	1.46			88.84	6.445	0.20	...	...	0.34	0.64
"	32.50	22.8	0.6	35.8					3.29		2.14				
"	60.01	10.0	1.7	24.8	0.6	2.8			4.80		3.10				
Renazzo	44.75			16				1.5		1.25(+0)	1			(Fe ₂ O ₃)	43
Rittusgrün	0.98			0.15	0.25					0.58(+0)				(MnO ₂)	9.31
Shonmeyer	61.88	9.12		25.83				0.33							0.46
Rochester Ind. Smelt	34.55	27.75	...	36.38	...	0.46									
"	37.81	11.04	0.23	24.97	5.31	0.84		0.10							
Saurette	34	38.03		14.5				0.01		0.33	9			0.83	3.31
Schie									84.2	14.4	0.49	...	...	...	...
"	37.8	27.44		31.68	3.08										
"	57.1		5.62	19.46	1.47				(Fe ₂ O ₃)	14.72					
Pravet	66.	5		20	...						(FeS)	12			
Seres	28.7	29.6		40.		0.9	0.8								
"	49.83		5.33	14.48	3.64	1.47	3.22	0.95	(Fe ₂ O ₃)	9.02	0.19			4.57	

	SiO ₂	FeO	Al ₂ O ₃	MgO	CaO	K ₂ O	Na ₂ O	Fe ₂ O ₃	Co	MnO	S	H ₂ O	As	Fe ₂ S ₃	Eu
Shalka	68.6		0.5					2.00			01	0.12	...	26.8	
Sheryotty	50.21	17.59	5.90	10.00	10.41	1.28	0.57	4.57							
Sidna	46.66	34.66		22.66											
"															
Klaproth	44	25		22.5					75.00	25.00					
Klaproth	48.25		14.50	2.00	9.5				2.25	5.4	0.25				
Moser	46.25		7.12	2.5	12.13				2.25	45.00	5.00				
Lammelsberg	48.3	19.32	12.65	6.87	11.27	0.62	0.26	0.57			0.81				
" 34.98%	46.19	0.83	31.26	1.12	16.98	1.14	0.5							2.93	
" 65.02%	49.44	28.31	2.64	9.97	8.2	0.35	0.1			1.25					
Vauquelin	50		9.		12					1.				29	
Atich	31.32	27.95		34.43		0.5		4.37	0.35						
"	47.44	10.72	9.97	21.33	5.10	3.17			1.21		0.64				
Steinbach vide Litteratur															
Stewart Co. & Smith	41.08	18.45	0.32	41.06					0.75						
"	56.03	16.21	5.89	21.00	0.10	2.97			86.92	12.01					
St-Mesmin	17.00	11.84		19.54		1.92									
40.6%	21.10	5.37	3.	6.1	1.09	1.21	2.18		4.94	0.72	7.58			2.99	

	SiO ₂	FeO	Al ₂ O ₃	MgO	CaO	Na ₂ O	K ₂ O	Fe	Co	Mn	Su	S	Fe ₂ O ₃	P	Cl
Tabor Howard	45.45		17.27						2.72				42.72		
Tadjera Mennier	s 24.70	6.10	0.44	23.36					8.32			(FeS) 8.04			
" 28.88%	i 14.50	8.08	1.20	2.32	2.66			0.12							
Timochin Scheerer	39.00		20.							+8.6% loss			17.5		
Klaproth	38.00	1.00	14.25	0.75						do			25.00		
Fourmes la grosse. Pisani	37.47	13.89	3.65	14.25	0.75	2.26		(FeO) 0.71	11.05	(+0) 1.30	0.17	2.21			
48.9%	s 17.10	10.35	0.73	24.4	2.61	6.03									
51.1%	i 27.20	6.10	3.59	19.8	0.64	2.65									
Trenzano Curioni	n.m 41.8	20.12	3.00	21.3	2.35	2.38	1.98					(FeS) 6.42			
22.78%	m							91.6	8.4						
Uden Seelheims	44.579	22.409	4.1	20.667	2.276	0.94	0.49		(FeO) 1.767	(+0) 0.288	0.43	(FeS) 0.768			
Utrecht Baumbauer m													0.04		
54.11%	n.m.s 16.682	10.13	0.66	17.75	0.17	0.121	0.013	(FeO) 0.266	86.75	12.97	0.24	(FeS) 7.623			
45.89%	n.m.i 55.456	11.09	4.229	17.936	3.002	3.829	6.252	(FeO) 2.176	(+0) 1.425	0.61					
Villanova Bertolino	s 12.15	7.45		13.23	1.60				20.70	3.68		(+0) 0.50			
i 27.51	4.78	0.42	1.54	0.88	2.54			0.04							

SiO₂ FeO Al₂O₃ MgO CaO Na₂O K₂O Cr₂O₃ Fe Co Ni MnO Cu Zn Cu S P Fe₂O₃

Unconformity. Smith	min																
		SiO ₂	FeO	Al ₂ O ₃	MgO	CaO	Na ₂ O	K ₂ O	Cr ₂ O ₃	Fe	Co	Ni	MnO	Cu	Zn	Cu	S
	S	84.52	30.01	0.43	32.5		0.87	.....			86.18	12.02	0.61	0.64	.....	.....	.....
	i	54.02	18.1	2.30	23.45		1.58	.....			0.31		0.36				
Wauwatosa No. Smith	S	33.02	37.57	0.12	28.41	.....	0.07				1.54						
	i	58.90	10.2	0.2	22.41	7.62	1.00		0.33								
Wesely		39.		0.16	6.00	3.00				12.33	0.59		6.66			22.66	
do		42.8		0.27	7.83	3.8				27.77	3.5		8.90			5.13	
do		36.37		0.84	8.53	4.7				25.99	2.7		6.87			14.00	
Wesley		51.5			13.00											38	
Wardens		41.		1.00	16.00	3.00			2.3				1.3			2.3	
Wald College Howard	A/T	50	32.00		24.66												
Patonjiku Langier		41.00		0.75	14.9	2.00			(0.75)			1.00				4.90	45.00

TABLE. II

Composition of Meteoric Iron. - Complete Analyses

Fe	Mt	Co	low	&	C	Grafito Mg Ca	NatK	Residue
-------------	----	----	-----	---	---	---------------	------	---------

Agram	vide <i>Strasburga</i>	
Arva	<i>Patara</i>	93.13 5:94

Bergemann	81.90	7.17	0.36	0.35	1.56	2.03	6.63
Love	90.92	7.32	0.94	0.44			1.17

Arkansas J. L. Smith 9.23 7.21 0.71
Wisherville, vide Black. Mts.

Alacama	Damour	92.03	7.00	0.62	0.21
---------	--------	-------	------	------	------

Field	87.80	11.88	0.30
-------	-------	-------	------

Frappoli	88.61	10.25	0.70	0.22	0.33
				0.22	0.13
					0.36

Allen Turner 93.40 6.62 0.53

Rivero	90.40	8.60	0.30
--------	-------	------	------

90.241 9.759

Species	Mean	SD	SE	95% CI
<i>Ischermak</i>	91.53	7.14	0.41	0.44

return, vide Macon Co

Augusta Co vide Virginia

Residue

	Fe	Ni	Co	Cu	P	S	Si	Fe ₂ O ₃	Al	G	Residue
Barthago	90.02	7.83	0.24		0.09		0.61				1.21
Chocoma	93.01	4.32									0.70
Cousville	95.00	5.00	.....				.....				
Chaitorne	83.57	12.665				2.895				0.907	
Jackson	66.56	24.708				4.000				1.480	3.24
Quaywater	92.15	7.37	0.28								
Gocharula into Santa Rosa.											
Robertson	89.59	9.12	0.35		0.04						
Costy Creek	90.09	6.52	0.33		0.02						
Boy	91.72	5.84	0.81	(+ 50)	0.22	0.19				0	0.8
Shepard	93.916	4.552									0.10
Frost-	87.00	12.00	0.50								0.50
Grantbourne	95.43	3.40	1.00								.....
Camterland Hills into Campbell Co.											
Dakotah	91.71	7.08									
Danville, Va.	89.513	9.05	0.521	.....	0.019	0.105					
Denton Co. Texas.	94.02	5.43	.....								0.33
Riddell											
Madeline	92.099	7.530	.....	.....	0.001						

7c Ni Co Cu P S Si Fe Mn Mg

Combustible Residue

Durango Danvers
Klaproth
John

0.23

93.38 5.89 0.39

96.75 3.25

91.50 5.5 2.0

Albion Bepeluis
John

88.23 8.52 0.76

87.50 8.75 1.85

97.5 2.5

88.02 8.88

Eldorado. Shepard

Fort-Perre vide Nebraska

Franklin Co. Ky. Smith

90.58 8.53 0.36 0.05

Greenville vide Babb's Mills

Groas-Cotta Staidinger i 75.4

Guernsey's Smith

87.01 12.36 0.42 0.12 1.08

Hauptmannsdorf vide Braunau

Haidelberg Wawinkiewicz

94.75 0.071 0.047 1.229 0.214

0.28

2.21

1.90

3.50

21.4 3.12

	Fe	Ni	Co	Cu	P	S	Si	Su	Mn	Al	Ca	K ₂ O	Read.
Senarto Clark	90.163	6.553	0.502	0.08	0.482	0.8 - 0.145	0.01	0.61	0.77	0.23	0.63		1.226
Holger Uehle	85.04	8.12	3.59										
Lion River Shepard	89.119	8.283	0.653	0.002									
" Los Angeles Smith	93.3	6.7						0.01					3.52
Easttown Shepard	80.74	15.73						....					0.58
	95.759	3.66	....										
Macon Co Ga. Shepard	94.58	3.015		0.129				(+0)	1.753				0.823
Madison Co. N.C. vide Jewell Hill													
Marshall Co Ky. Smith	90.12	8.72	0.32	0.10									
Mexico Smith	91.03	7.557	0.763	....	0.20	....							
Mistecu Bergemann	86.875	9.917	0.745	0.07	0.553								0.975
New Weston Tenn. Frost	96.00	2.40											
Nebraska von Proct	94.288	7.185											
von Madelung	90.764	7.607	0.889	....	....								- 0.053
Nelson Co Ky. Smith	93.10	6.11	0.41	0.05									
Newstead Thompson	93.51	4.86					0.42

Fe Ni Co Cu Pb S Li C unal Ca Fe₂O₃ Sn

Atiakonak Forchhammer

93.52 1.61 0.25 0.49 0.18 0.39 1.76

Uktihha Co. Taylor

37.7 59.69 0.40 0.90 0.10 0.12 0.20 0.09

Orange River. S. Africa. Shepard.

90.48 8.94

Wroptawlsk Sokolowskij

97.29 2.07

Swanow

93.63 7.00

do

94.12 6.96

Pittsburg Gentz

92.809 4.665 0.395 0.084 0.251 0.037 0.141

Dramtanam Baumhauer

93.7 2.88

do

96.7 5.91

Pulnam Co. La. Shepard

89.52 8.82 1.66

Rasgata Uöhler

92.35 6.71 0.25 0.35

Ryeis and
Boringauet

90.98 7.8

Red River Texas. Shepard

90.02 9.67

Lockingham Co. N.C. Gentz

90.41 8.74 0.11

Smith

90.88 8.02 0.50 0.03 0.03

Logue River Mts. Ar. Jackson

89.00 10.29

0.729

0.445

0.74

[illegible]

Name		Fe	Ni	Co	Leu	P	S	Sial	Ca	C	Mm	Fe ₂ O ₃	SiO ₂	Residue
Wright Shepard		99.68						0.2	....	0.09				
Berlaseen Rammelberg		92.33	6.23	0.67	(+50) 0.06			0.02		0.52				
Duftus		90.00	5.308	0.434	0.104			1.137			0.912	....		0.884
Seneca Falls Shepard		92.40	7.60											
Smithland Ky Frost		90.00	10.00											
Fabry Eberhard		92.76	5.69	0.79		0.86								0.28
Maopaca Darlington		93.61	4.62	0.36										1.21
Lagewell vid. Dalton Co														
Folucca Bergemann		85.49	8.17	0.56										5.00
Bocking		87.88	9.28	0.80										2.04
Asor		90.13	7.24			0.37								0.22
Pugh		87.89	9.05	1.07		0.62								0.56
do		90.43	7.62	0.72		0.15								0.90
Martius		89.22	9.51			0.20								0.30
Taylor		90.72	8.49	0.44		0.18					0.25			0.38
Uricoechea		90.40	5.02	0.04		0.16								4.10
Trenora Uric. Smith		91.03	7.20	0.63		0.14								

[illegible]

Fe Ni Co Cu P S Si G

Xiquipico Dugh

87.88 8.86 0.89 0.86 0.24
88.28 8.90 1.04 0.78 0.22

1.24

Taylor
do

90.08 7.10
90.37 8.79
90.72 8.49 0.44 (Pn) 0.18 0.25

Zacatecas Bergemann
Miller

85.42 9.73 0.44
90.51 5.81 0.48 (Pn) 0.50 0.24
2.53
2.66

TABLE III

Composition of Residues from Meltonic iron in Hydrochloric acid Solutions, Schreibersite.

	Fe.	Ni	Co	Mg	P.	Atomic Proportions P:R.
Area	a. 87.20	4.24			7.26	1:1.7
	b. 78.36	15.47			6.14	1:18.4
Bohemilitz	69.45	15.79			14.76	1:3.1
Braunau	60.13	27.15			12.72	1:3.7
Cashy Creek. (a)	87.77	8.92			3.31	1:16.0
Strogen	68.11	17.72			14.17	1:3.3
Knoxville	56.60	26.76	0.34		14.39	1:3.1
Claraca (Mexico)	58.36	29.95			11.61	1:4.1
Pallaresen	48.67	18.33	9.66		18.48	1:2.83

Atomic proportions P:R

Santalosa (a)	42.07	28.57	1.60	14.30
Schurty	22.34	36.66	5.00	36.00
Seelasgen	62.63	29.18	0.82	7.37
Toluca (Acotitlan)	86.32	10.14		3.54
Toluca	57.11	28.35		15.01
Pacatecas (a)	75.02	14.62		10.23
(b)				24.00

	Fe	Ni	Co	Cu	P
Atomic proportions P:R					
					1:2.8
					1:0.95
					1:7.0
					1:15.0
					1:3.0
					1:4.2

Bergemann
Heunier

TABLE IV
Composition of the Chondrites (

Meteoric Iron. Iron sulphide. Chondritic Fe. Silicates Graphite

Alessandria	20.45	10.53	1.81	67.21	Mussaghi. Pogg. Ann. 118. 361
Bachmut	11.0	5.0	2.00	81.01	Wöhler: Wiers. Ak. Ber. 46
Blansko	20.13	2.97	0.63	76.27	Berzelius Pogg Ann 33. 8
Borkut	21.07	3.16	0.63	75.14	Kurisanv Wien. Ak. Ber. 20. 398
Bremerswörde	23.15	-	0.31	76.05	Wöhler. Pogg Ann. 98. 609 *
				0.14	Ann. Ch. und. Pharm. 71. 311

Composition of Condrites

386

	Fe.	Fe _x S _x	FeO, Cr ₂ O ₃	Silicates	Graphite	
Buschof	5.69	5.93	0.33	87.90		Grewick u. Schmidt. Dorpat. 1864
Casale	23.02	1.37	0.66	75.55		Bertolini. Pogg Ann. 136. 594
Chantonmay a.						Bergelius
6 b	7.89	6.16	0.97	82.77		Lammeltsee
Chateau-Lenard	9.25	0.96		89.79		Dufröy. Pogg. Ann 53. 411
Dacca	10.56	2.05		87.39		Hein: Urv. Ak. Ber. 54. 558
Danville Ha.	3.1			96.9		Smith: Am. J. II 49.1
Thurmshala	8.42	5.61	4.16	81.81		Haughton. Pogg Ann. 136. 447
Dundrum	20.60	4.05	1.50	73.85		do do 136. 455
Ensisheim	9.0	5.64	0.6	84.0		Crook. Owens met. of met. stones. Göttingen
Girgenti	8.3	5.2	1.1	85.4		Vom Rath: Pogg Ann. 138. 544
Guernsey Co. Da.	10.7			89.3		Smith Am. J. II. 30. 31
(New Concord) Vt.	6.11			92.86		Madelung. Dissertation. Göttingen 1862
Harrison Co. Ind.	5.00			95.00		Smith Am. J. II 28. 409
Honolulu	4.32	6.30	1.35	86.12		Kuhlberg. Pogg Ann. 130. 446
Kakora	1.39	.....	0.01	98.60		Starris Ann. Ch. Ph. 110. 225

Composition of Chondrites

Meteorite

Fe

Fe₂O₃

Silicates

Graphite

Killer

Klein Wenden

Krähenburg

Simco. Iowa

Lixna

Mauerkirchen

St-Mesonium

Nygo Madaras

Montrejean (a)

(Aurleon) (b)

Mudders

Murcia.

Ind. 2nd 1/2 / 58

Nashville. Tenn

Nesft-

Rezel

Chabata

Ormans

Parnallee

Haughton. Ann. Ch. Ph. 113. 308

Rammelsberg Pogg Ann. 62. 449

von Rath Pogg Ann. 62. 449

Rammelsberg Monatsb. 1870. 457

Kuhlberg Pogg Ann. 136. 444.

Crook, S. Ensisheim

Pisani. C. Rend. 62. 1326

Wöhler Ann Ph & Ch. 96. 251

Danvers C. Rend. 49. 31

Harris. Ann. Ch. Ph. 110. 181

Crook. S. Ensisheim

Munier. C. Rend. 66. 639

Baumhauer. Pogg Ann. 66. 498

Kuhlberg: " 136. 448

Göbel. Pogg. Ann. 99. 642. Ann. Ch. Ph. 20. 387

Buckheimen Münster. Ber 31

Pisani. C. rend. 1868

Pfeiffer: Min. Ak. Ser. 47

80.15

87.8

84.62

86.76

63.33

81.70

85.90

78.24

63.21

90.36

86.70

Composition of Chondrites

	meteoric Fe.	Fe Sx	Fe Cr ₂ O ₄	Silicates	Graphite	
Pillistfer	21.67	9.38	0.71	68.12		Greunigk s. Buschof
Kulluok u.	10.06	3.86-		86.09		v. Rath. Fest. d. Nieder. G. z. J. d. Univ. Bonn
b	21.08	4.86	1.30	72.76		Wenther. J. f. pr. Chem. 105. 1
c	21.78	2.77	1.30	74.15		Kammelsberg. Monatsb. 1870. 448
Richmond Va.	8.22	4.37		87.41		do 1870. 453. Shepard. Am. J. II 89
Id. 7/9/68 Sanguis. Series	8.05	3.04		90.48		Meunier. s. Murcia
Shergottite Skge.	9.14		0.32	79.88 or 89.34		Bergelius Reg. Ann. 16. 611
Skauropot	8.22	4.32	0.26	87.20		Crook. s. Ensisheim
Judgeria fd. 9/67	10.25	2.95		86.82		Dittler. J. f. pr. Chem. 64. 121
Journimus-la-grasse.	8.32	8.04	0.20	83.54		Ulrich. Z. Naturf. 2. 439
Uden	8.67	6.06	0.71	84.28		Meunier. s. Murcia
Wacht	1.77	0.72	0.76	96.18		Pisani. C. rend. 58. 169
	9.14	5.10.	0.20	86.56		Baumhauer. Reg. Ann. 16. 184

TABLE V

Composition of the Silicates in Chondrites

	SiO_2	Al_2O_3	FeO	MgO	CaO	Na_2O	K_2O
Arman	34.58	4.78	30.53	27.00	2.51	0.61	
Dacca	37.90	3.03	26.69	27.41	1.34	2.47	1.16
Sures	39.58	2.70	22.67	26.30	1.86	1.51	3.26
Buschof	40.96	2.82	23.82	30.91	0.81	0.30	0.37
Kakoba	41.24	2.46	24.60	27.06	1.51	1.92	0.26
Muddoor	41.78	2.99	20.67	32.98	0.89	0.38	0.31
Ensisheim	42.51	2.75	36.49	15.62	1.96	0.45	0.28
Chateau-Renaud	42.60	4.34	32.55	19.02	0.20	0.98	0.31
Staurhof	43.57	5.15	14.18	31.97	2.63	1.12	0.79
St-Mesmin	43.70	3.41	19.78	29.49		3.58	
Tournines	44.01	4.24	16.56	29.20	3.05	2.63	
Charbonnay a	44.16	2.95	19.45	27.79	1.52	1.24	
b	45.16	3.06	18.05	30.65	1.70	1.38	
Durlemont	44.46	4.33	16.48	28.95	3.10	2.21	
Maurbach	44.81	1.84	24.55	26.10	2.28	0.26	0.16

(1) According to Reichenbach 107, 1736) Bergelius has (a) examined under this name an entirely different meteorite. This supposition is refuted by Rammelsberg's analysis (b)

Composition of Silicates in Chondrites

	SiO ₂	Al ₂ O ₃	FeO	MgO	CaO	Na ₂ O	K ₂ O
Montenapian	47.22	2.27	20.97	27.30	0.98	0.69	0.14
	44.68	2.61	20.94	29.71		1.81	0.21
Pullusk	48.88	1.27	16.71	31.26	0.82	1.56	
	45.88	2.11	20.00	30.51	1.57		
Shergottay	45.83	2.34	21.20	30.16	0.55	0.28	0.14
Horoboluk	46.04	2.24	22.24	28.46		1.02	
Parnallee	46.03	2.78	19.67	27.11	0.71	1.96	0.58
Murcia	46.14	0.80	8.26	44.10	0.14	0.55	
Bachmut	46.18	3.38	18.58	29.19	1.78	0.55	0.27
Klein Wenden	46.18	5.23	11.21	32.75	3.66	0.41	0.53
Richmond	46.18	2.53	15.82	32.41	3.06		
Skyl	46.26	2.46	21.22	26.82	2.87		
Uden	46.35	4.26	24.05	21.49	2.36	0.98	0.57
Krahenburg	46.37	0.67	22.56	27.13	2.15	1.12	
Borkut	46.53	3.61	16.88	26.24	2.58	2.51	0.82
Ulrecht	46.55	2.88	18.51	28.61	1.73	1.66	0.27

Composition of Silicates in Chondrites

	SiO_2	Al_2O_3	FeO	MgO	CaO	Na ₂ O	K ₂ O
46.57	4.10	18.66	29.79	0.06	0.76	0.10	
46.61	1.68	18.22	28.89	1.99	1.61		
46.77	3.23	16.91	32.17		0.92		
47.30	0.31	25.23	24.53	0.02	1.04		
43.50	2.48	26.76	25.27	2.71			
46.88	2.40	17.49	31.36	1.41	0.46		
47.05	1.98	16.97	30.63	3.24			
47.06	2.35	26.05	27.61	0.81	0.42	0.68	
47.64	6.14	17.35	27.29	0.84	0.40	0.02	
48.27	1.68	21.27	24.45	2.97	0.31	0.39	
48.95	2.94	11.54	32.49	1.22	0.98	0.24	
49.45	2.51	14.19	29.35	2.36	1.09	1.05	
50.33		4.52	44.09	0.56		0.50	
50.37	0.76	15.13	32.10		0.36	0.29	
51.39	1.16	11.18	30.34	2.60	0.99	0.57	
53.63	0.57	18.86	20.12	1.19	5.62(?)		

Ault-
 Sargent
 Lina
 Querny Co. a
 L
 Linn Co Iowa.
 Tadiara
 Harrison Co
 Nashville
 Danville
 Blansko
 Osel
 Sauquoit
 Purnsala
 Dundrum
 Casale

Combination of Silicates in Chondrites

SiO ₂	Al ₂ O ₃	FeO	MgO	CaO	K ₂ O
54.43	3.93	6.14	29.71	2.25	2.91
58.65	3.66	3.40	34.74	0.70	0.50
57.90	0.44	3.01	37.10		1.55
59.63	13.78	3.76	17.81	6.00	!?
59.70	3.08	5.73	29.46		1.55

Hezo-Madaras.
 Willis Ter
 Chaba
 Alessandria
 Bremerörde

TABLE VI

Proportion of the decomposed portion A to the undecomposed B. part of the Chondrite Silicates.

A : B found. A : B calculated

Amans	83.1 : 16.9
Seres	47.5 : 52.5
Kakora	56.7 : 43.3
Muddoor	52.2 : 47.8
Insheim	81 : 89

346 : 454

Ratios of Smectite Silicates

	A: B. Found	A: B calculated
Chateau Peroud	57.5 : 42.5	
Skauvaboel	54 : 46	48.3 : 51.7
St. Mermin	57.8 : 42.2	
Tourismes	49 : 51	
Liantonmay a	51 : 49	47 : 53
b	51 : 49	
Mauer Kirchheim	61 : 39	67 : 33
Monrejean a	54 : 46	
b	56 : 44	
Pullist a	42.6 : 57.4	
b		44 : 56
c		45.3 : 54.7
Shergotty	52 : 48	57 : 43 (?)
Parnallee	54.2 : 45.8	
Murcia	61 : 39	59.5 : 40.5

Ratio of Condrite Silicates

A: B Calculated,

A: B found

Bachmut

Klein Wondere

Richmond

Steye

Uden

Borkut

Utrecht

Sixna

Guernsey a

b

Linn Co

Tadysa

Harrison Co

Nashville

Dunville

Blanco Co

51 : 49

42 : 58

52.8 : 47.7

56 : 44

57.5 : 42.5

48 : 52

50 : 50

50.7 : 49.3

63.7 : 36.3

57.6 : 42.4

50 : 50

65.5 : 34.5

62.5 : 37.5

50 : 50

61 : 39

50.2 : 49.8

36.4 : 63.6

	A : B	found	A : B. Calculated
Osseel	50.6	49.4	
Sanguis	74.3	25.7	
Thurmsala	55.4	44.6	
Dundrum	44	56	
Vasale	47	53	
Mepö-Madans	62	38	
Orata	29	71	

Table. VI

Composition of (A). Silicates of Chondrites
Decomposed Portion

	SiO ₂	Al ₂ O ₃ (mm)	MgO	CaO	K ₂ O	Atomic proportions	R ⁺ :Si	Al ₂ :R ⁺	Fe (mm): Mg (Ca)	R ⁺ :R ⁺	Fe (mm): Mg (Ca)
Arans	33.37	3.93	34.59	26.36	1.74		2.1	1:20	1:1.44		
Seres	28.7		29.6	40.0	0.8						
Kakoa	34.4		34.38	19.75	1.23		1.95			1	0.86
Muddoor	36.46	0.44	24.36	38.61	1.13	End					
	38.32	0.42	23.29	36.90	1.07	reptd					

Composition Decomposed Portion A. Chondrite Silicates

	SiO ₂	Al ₂ O ₃ (Mm)	MgO	Na ₂ O	K ₂ O	R ₂ : Si	atomic proportions Al ₂ : R ² : Fe(Mm) : Mg(Ca)
Ensisheim	31.85	0.61	52.90	13.72	0.92	2.06 : 1	1 : 0.5
Château Renard	36.17		44.16	19.73		1.87 : 1	1 : 0.8
Stauropol	34.60		26.80	38.04	0.56	fd (2)	
	39.43		16.60	43.35	0.60	spid	1 : 4.7
St. Mesmin	33.80		23.54	38.84	3.81	2.4 : 1	1 : 3
Tourmaies	34.70	1.49	21.12	40.41	1.30	2.32 : 1	1 : 3.5
Chantemay a	32.61		29.62	34.36	0.45	fd (3)	
	39.05		18.63	41.15	1.17	spid	1 : 4
b	33.33		23.74	38.93			
Mauerkirchen	32.68	0.36	28.91	37.44	0.61	fd	
	37.72	0.33	26.74	34.64	0.57	spid	1 : 2.4
Montrejean a	39.10		25.71	34.07		1.9 : 1	1 : 2.4
b	38.32		29.32	32.54		1.9 : 1	1 : 2.0
Pullusk a	35.4	0.7	24.9	39.9		fd (4)	
	39.67		16.64	43.69		spid	1 : 4.7

Composition of Recrystallized Portion A

Chondrite Silicates

Atomic proportions
R": Si Ca₂: R" Fe(Mn): Mg(Ca)

SiO₂ Al₂O₃ (mm) MgO CaO Na₂O K₂O
FeO

Fuller's

40.53 13.08 44.36 2.04 rep.

{ 82.34 29.65 38.01

{ 40.39 13.04 46.57

Shergottite
Pamaree

39.02 0.34 21.62 39.02

37.97 2.36 26.21 32.74 0.72

Murcia

38.73 12.93 47.21 0.23 0.90

41.34 7.07 50.39 0.24 0.97

Bachmut

36.86 26.84 35.65 0.50

Kleinwandere

39.90 10.91 47.37 2.12

Richmond

39.30 18.21 41.67 0.80

Skepe

37.81 27.44 31.67 3.08

Uden

36.02 32.68 26.94 0.50

Borkut

35.76 3.04 12.35 36.95 1.20 1.26 6.50 5)

Utrecht

36.66 0.14 13.46 38.96 0.40 0.28 0.10

Guernsey Co. L.

35.37 29.26

Lewis Res

38.80 21.31 39.89

1: 6.4

1: 3.3

1: 2.3

1: 6.6

1: 13.0

1: 2.4

1: 8.1

1: 4.2

1: 2.2

1: 1.5

1: 3.0

1: 3.0

1: 1.5

1: 3.4

Composition of Decomposed Portion A. Chonchite Silicates

	FeO					Atomic Proportions.	
	SiO ₂	Al ₂ O ₃ (mm)	MgO	CaO	K ₂ O	R ⁺⁺ : Si	Al ₂ : R ⁺⁺ : Fe (mm) : Mg (Ca)
Judaea	45.24	0.80	11.17	42.78		1.62 : 1	1 : 6.1
Nashville	37.84	0.52	18.40	41.62	0.68	2.1 : 1	1 : 4.1
Danville	47.11	1.77	22.19	27.22	2.37		
Blansko	33.08	0.33	27.39	36.14	0.46		
				(H ₂ O)			
	40.62		9.93	47.75	1.70	106%	1 : 8.6
Desel	40.27	0.43	17.86	39.59	0.63	2.0 : 1	1 : 4
Sanguis	45.66		3.05	50.70	0.60	1.73 : 1	1 : 29
Dharmada	39.75	0.29	18.37	38.47	0.28	1.85 : 1	1 : 3.8
Dundrum	38.74	0.45	16.70	40.93	0.84	2 : 1	1 : 4.5
Basale	35.59		21.64	38.42	4.66 (2)		
Mesa Maxima	51.84	5.08	37.64	1.70	3.44	1.2 : 1	1 : 19.6
	48.27	5.41	0.52	11.00	1.82	1.67 : 1	

TABLE VIII

Composition of the Undecomposed Part B
Chondrite Silicates

T O M I O P R O P O R T S

Fe: (MgCa) R': R" Al₂: R"

SiO₂ Al₂O₃ Mn^{FeO} MgO CaO Na₂O K₂O
69.91 1.07 16.40 3.91 2.24 6.48 (1)

Lasale

Sanguis

Dummsala

Dundrum

Mego Mudaras

Mauerkirchen

Ensisheim

Osael

Blansko

Mucia

Arushville

St-Meemin

Steyr

Ulrich

1: 1.34 1: 5.6

1: 1.38 1: 4⁽²⁾ 1: 30 1: 58

1: 1.4 1: 6.5 1: 13.5 1: 44

1: 1.47 1: 2.1 1: 7.5 1: 38

1: 1.7 1: 1.2 1: 17 1: 14

1: 1.4 1: 3.5 1: 13.6 1: 12

1: 1.32 1: 3.6 1: 7.0 1: 17

1: 1.3 1: 5 1: 15.6

1: 0.97 1: 7⁽²⁾ 1: 49.6

1: 1.7 1: 1.5 1: 5

1: 1.46 1: 2⁽²⁾ 1: 7.3 1: 8.2

1: 1.05 1: 2.8 1: 17

1: 1.25 1: 2.7 1: 18

(1) R²⁺ R combined (2) = Ca Fe

Composition of the Undecomposed Portion B

Chondrite Silicates

	SiO ₂	Al ₂ O ₃ (m)	FeO	MgO	CaO	Na ₂ O	K ₂ O	ATOMIC RATIOS		
								R" : Si	Fe : (Mg+Ca)	R' : R" al ₂ : R
	52.07	4.48	20.74	20.72	1.13	0.58	0.28	1 : 1.03	1 : 4.8	1 : 32 1 : 19
	51.76	16.22	17.50	18.32	0.46	2.30	0.68	1 : 1.11	1 : 1.9	1 : 8 1 : 7.5
	51.00	9.05	11.42	22.07	4.80	0.71	0.92	1 : 1.03	1 : 4	1 : 18.6 1 : 9.3
	50.42	4.17	27.75	8.07	9.25			1 : 1.10	1 : 1	1 : 19
	50.21	5.68		36.63	1.87	4.43	0.60	1 : 0.8		1 : 6 1 : 18.6
	50.08	4.11	19.85	20.14	3.90			1 : 0.98	1 : 2.0	1 : 21
	49.83	5.14	12.54	14.48	3.54	1.47	3.22	1 : 1.26	1 : 2.4	1 : 5 1 : 13.2
	47.44	9.97	11.93	21.33	5.10	2.18	0.97	1 : 0.95	1 : 3.75	1 : 9 1 : 8.6
	48.68	5.76	26.82	26.82	0.63	0.80	0.67			
	45.95	6.07	28.25	28.25	0.66	0.84	0.71	1 : 0.78	1 : 3	1 : 21.3 1 : 17
	46.43	8.98	10.55	30.14	6.30			1 : 0.63	1 : 8	1 : 10

(1) Ca = free

Shergottite
Chladni-Elchard

Klein Wenden

Tadysira

Kakora

Danville

Seres

Steinbock

Muddoor

Ormans

showing the days of each month on which aerolites have fallen
to the earth.

[illegible]

TABLE X

Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
1825	1853	1849	1851	1848	1843	1847	1841	1834	1849	1850	1846
1824	1848	1843	1844	1846	1841	1843	1836	1852	1844	1846	1836
1810	1847	1841	1842	? 1831	1838	1842	1829	1843	1838	1839	1833
1796	1839	1820	1838	1827	1834	1840	1823	1833	1827	1835	1813
	1830	1818	1812	1808	1828	1837	1822	1829	1824	1833	1807
	1827	1813	1812	1806	1822	1835	1818	1826	1819	1822	1803
	1825	1811	1808	1791	1821	? 1831	1812	1825	1815	1820	1803
	1824	1807	1804		1819	1820	1810	1822	1803	1814	1798
	1818	1806	1799		1818	1811	? 1800	1822	1791	1811	1796
	1815	1805	1795		1809	1810		1814		1806	
	1814	1798			1806	1803		1813			
	1796	1796			1794	1790		1808			
								1802			

PERIOD OF 63 YEARS

Showing the months
in each year in
which anolytic falls
have been observed

PERIOD OF 100 YEARS.

PERIOD OF 200 YEARS

Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
1717	1785	1683	1780	1751	1752	1766	1789	1775	1787	1773	
1697	1671	1654	1750	1698	1723	1756	1766	1768	1750	1768	
1683	1647	1636	1620	1680	1668	1753	1738	1753	1740	1639	
1622			1715	1677	1635	1727	1650	1650	1674	1627	
			1620			1725	1642				
						1647	1828				
						1635	1618				
1585		1596	1540	1580	1591	1581		1511		1492	
1496		1583		1561							
		1491		1552							
				1520							
				1379							
1328						1249			1304		856

TABLE XI

Showing the time of day in which meteorites have fallen.

A. M.

Hours

12-1

1-2

2-3

3-4

4-5

5-6

6-7

7-8

8-9

9-10

10-11

11-12

Totals

AM

2

1

3

3

7

7

4

6

33

7

6

11

20

14

14

8

6

10

4

2

102

Totals PM

TABLE XII

Countries	Stones	Iron	Total	average Latitude
France	34	1	35	46° N
Ireland and Great Britain	20	1	21	53° N
Bavaria, Prussia, Germany	37	6	43	51° N
Hungary Bohemia; Austria	28	5	33	48° N
Switzerland	2	....	2	46° N
Lombardy, Piedmont	33	1	34	43° N
Sicily, Italy				
Portugal and Spain	7	....	7	40° N
European Russia	14	1	15	54° N
Finland and Siberia	4	3	7	63° N
Sweden	1	....	1	60° N
Asia minor, Crete, Turkey	10	1	11	40° N
Egypt, Arabia and N. Africa	6	1	7	30° N
Tartary, Persia and Central Asia	1	2	3	35° N
Japan and China	23	....	23	18° N
Ceylon and India	19	3	22	20° N
United States	18	34	52	35° N
Greenland	1	1	2	65° N
West-Indies and Mexico	2	8	10	25° N
Sandwich Islands	1	....	1	20° N
South Africa	2	2	4	30° S
Java	1	....	1	10° S
South America	1	5	6	
Totals	264	74	338	

TABLE XIII

Showing the number of Meteoric Depositions recorded, arranged according to zones of Latitude. North.

Between N. Latitude	5°	and	10°	3
"	10	"	20	16
"	20	"	30	34
"	30	"	40	72
"	40	"	50	127
"	50	"	60	67
60 "	60	"	70	8
				327

TABLE XIV

Showing the proportion of falls for several countries since 1790

unit = France

Great Britain & Ireland

Spain

Germany

Austria

Italy

European Russia

United States

actual No. compared No.

19

19

11

12

3

9

11

13

14

13

11

14

12

30

31

18

8

39

TABLE XV

Total number of falls for each month, from the year A.D 1500 to 1854.

Month.	No.
January	9
February	15
March	17
April	14½
May	15
June	17
First-half-yearly total	87½
July	19½
August -	15
September	17
October	14
November	15
December	9
Second half-yearly total	89½
Average.	14.75

Catalogue of Meteorites

From 1866 - 1878

Number whose time of fall is known	70
Number whose time of fall is unknown	64
Total	<hr/> 134

Time of Fall. known.

Weight Density Latitude Long. Grch.

1.	1860 Feb 2	Alessandria Piedmont				
2.	Mar 28	Khuragurh S. E of
Bhurtpur India	3.391	26° 56' 30" N	77° 53' E	
3.	May 1	Guernsey Co Ohio
Three stones 52.40 & 41 lbs	93 lbs	40° 4' N	81° 35' W	
4.	June 15	Laphoe Co. Donegal
Ireland		54° 30' N	7° 36' W	
5.	June 16	Kusiali village Ku-
maon District, British
Gurhwal India		30° N	79° E	
6.	July 14	Dhurnsala Pun-
jab India	175 gm
3.399
3.175
3.456	31° 55' N	77° E	Haughton
Haidinger
Jackson
7.	1861 Feb 14	Tocane St-Apre
Dordogne France				
8.	May 12	Butsura 100 miles
N. of Goruckpur
India	612 gm	3.60	27° N	88° 30' E

Time of Fall Known:

9.	1861	May 14	Canelas, near
Villa Nueva Catalou-
ia, 7 miles SW of
Barcelona Spain
thirty fragments.			41° 15' N	1° 40' E
10.		Spring	Ya-fa-ee, Mountains
Arabia felix (Yemen)	3 lbs 10 oz		15° N	48° E
11.		June 16	Groenja. Banks of the
Terek, Caucasus
Russia	18 grm		43° 30' N	45° E
12.	1862	Oct 7	Klein Menow Alt=
Strelitz Mecklenburg	10.5 kg	4.1	53° 20' N	18° E
13.		Nov 1	Sevilla Spain			37° 30' N	6° W
14.	1863	Mar 4	Veendam, Roermonde,
and Bar-le-duc France			48° 35' N	5° 10' E
15.		Mar 16	Pulsova. N.E of Ruttam
Indore Central India	48 grm		23° 30' N	75° E
16.		Mar 25	Wilmsdorf				
17.		June 2	Gross-Buschhoff, near
Jacob-Litz in Kurland
Russia	6.25 kg	3.62	63° 40' N	22° 40' E

Time of Fall known

18. 1863 Aug 8 Pillistfer Pastorate in 14.385 kg 3.663 58°34'41" 43°22'-25'E
Fellin Circle North
Livlands Russia
19. Aug 11 Dacca near Shygal ½ kg 3.55 24°N 90°30'E Hein
Bengal India
20. Aug 19 Walle, Wolmarshof 1.813 kg 3.565
21. Dec 7 Fournies-la-Grosse 7 kg 50°46'54"N 5°E
Tirlemont Belgium
22. Dec 10 Trapezunt 39°46'E
23. Dec 22 Manbhoon Bengal 1.5 kg 3.424
India
24. 1864 Jan 10 Brest
25. Apr 12 Verft-Kurland
Russia, Two stones 4.58 9.8 kg
5.3 kg
26. May 14 Montautan, Tarn-et- 2.567 44°N 1°25'E
Garonne, (Argueil)
France. several stones
one of them 14 grams

Time of Fall known

27.	1864 June 26	Dolgaja or Dolgowli volhynia Russia	1.6 or 1.5 kg		50° 30'	27°	
28.	1864 Dec 4	Turakina, Wellington New Zealand				175° E	
29.	1863- Jan 19	Mouza - Khoorna Lidowra, Goruckpore District India	3.578 kg		27° N	83° 30' E	
30.	Nov 25	Claywater Vernon Co Wisc. 2 fragments	3 kg	3.66	43° 30' N	91° 10' W	
31.	May 23	Gopalpur near Bager- haut, Jessore India Three pieces, wgt, 1.632 kg. 158 grms + 58 grms	2.37 kg		23° N	89° 30' E	
32.	Aug 12	Dundrum, Grassch Tipperary, Ireland	2.225 kg	3.066 to 3.57	52° 30' N	8° 5' W	Haughlow
33.	Aug 25	Aumale, near Senahd- ja, Constantine Algeria two stones	2.5 kg	3.65	36° 27' N	10° 20' E	Vatonne
34.	Sep 21 or 25	Muddoor, Mysore Madras Presidency, India, several.	2.121 kg		13° 30' N	77° 34' E	

Time of Fall known.

35. 1866 Apr South Canaries In- 87 gm
dia
36. May 27 Pokhara, near Busto 282 gm 27° N 83° E
tee (or Buste), Goruck,
poro India
37. May 30 St Mesmin Aube, 402 gm 3.426 48° 20' N 40 40' E Pisani
France, a number.
38. June 9 Knyahinya, Co of 298.42 kg 3.52 Haidinger
Ungvar Hungary
1000 stones
39. Oct 5 Jamkheir Bombay
India
40. 1867 Jan 19 Khetrie (Sank hoo; 76 gm
Phulee etc) Rajpootana
India
41. June 9 Tadjera near Guidjell 8.43 kg 3.54 36° N 40° E Moerous
Arondissement Setif 3.595 Meunier
province of Constantine
Algeria, several stones

Price of Fall known

42.	1868 Jan 30	Pullus (Sielce, Gostkowo etc) Poland	123 kg	3.94 3.66 3.537	53° N	21° E
43.	Jan 30	Gluzow near Warschau Poland	50 kg	7.017		
44.	Feb 29	Villanova and La Motta di Conti near Casale Northern Italy several stones	8.12 kg	3.29		
45.	Mar 20	Daniels Ruil Griguer Ter., S., Africa	17 gm			
46.	May 22	Slavetiz between Agram and Jaska in S. W. Croa- tia	1.327 kg	3.754		
47.	July 11	Arnans Doubs France	26. gm	3.599		
48.	Sep 6 or 7	Sanguis - St Etienne Dep. Basses-Pyrenees France	6 gm	3.369		
49.	Oct 1	Lodran near Moulton India	51 kg			
50.	Dec 5	Frankfort, Franklin Co. Ala	9 1/2 oz	3.31		

Time of Fall known

51.	1869	Jan 1	Hesse in Uppland Sweden 3-400 stones	162 gm	3.697		
52.		May 5	Krähenburg Pfalz Bavaria	15.75 kg	3.4975		
53.		May 22	Kernours near Elequeret Morbihan France	234 gm	3.747		
54.		Oct 6	Stewart Co Ga	12 1/2 oz			
55.		Dec 25	Mourzouk Barbary			12° E	26° N (Paris)
56.	1870	June 17	Abbenbüchen	199 gm			
57.		Aug 18	Murcia Spain				
58.	1871	May 21	Seas mont Waldo Co. Me.	109 gm			
59.		Dec 10	Bandong village Isle of Java, 3 pieces	10.92 kg	3.519		
60.	1872	July 23	Dep Loir-et-Cher, N.E of Tours Canton St- Amand. (Lance)	47 kg	3.8		
61.		Aug 31	Orvinio States of the Church. Province of Umbria 6 fragments	#1 4 3/4 gms #2 92 gms #3 622 "	3.65 3.73 3.64		
				#4 1242.5 "	3.7		
				#5 432 "			
				#6 1003 "	3.58		

Time of Fall known

417

62.	1874	May 12	Sevukow District of Belgorod, Gov. of Koursk	98 kg			
63.		May 14	Nash Co. N.C. 3 stones	300 kg	.2601	86° 11'	77° 50'
64.		May 20	Uirta (?) Turkey	25 lbs	27.86		
65.	1875	Feb 12	Iowa Co Iowa	500 gm		41° 40'	92°
66.		Aug 16	Frid-Chair Cuck of La. Calle Province of Constantine Algeria	380.666 gm			
67.	1876	June 25	Kansas City Mo				
68.		Dec 21	Rochester Fulton Co Ind nearly 400 gr Several stones	3.65	41° 8'	86° 12'	
69.	1877	Jan 3	Warrenton Mo	10 kg		38° 50'	91° 10'
70.		Jan 23	Cynthiana Ky	6 kg		38° 25'	84° 15'

Found.		Time of Fall Unknown		
1.	1860	Arkansas. Newton Co	653gm	$\frac{4.5}{6.1}$
2.	1860 Oct	La Grange Oldham Co Ky	112 lbs	7.9
3.	1860 Dec	Robertson Co Tenn	37 lbs	7.85
4.	1860	Oregon Rogue River Mountains		
5.	1861	Dacotah Territory	10 ^{lbs} 10 ^{oz}	7.952
6.	1861	Gran Tourne near Melbourne Victoria	3700 kg	
7.	1861	Rittersgrün Saxony	1.767 kg	
8.	1861	Breitenbach Bohemia	65 gm	
9.	1861	Newstead Roxburghshire Scotland	1.162 kg	
10.	1862	Sierra de Chaco Atacama	8 gm	
		a		
11.	1862 Oct	Rokitzan Bohemia	2 kg	6.005
12.	1862	Victoria W. Cape Colony S. Africa	892 gm	7.692
13.	1862	Howard Co Ind.	4 ^{lbs} 1/2 ^{oz}	7.82
14.	1862	Botetourt Va.		
15.	1863	Savisavick, N. Greenland		76°
16.	1863	Bückeburg, Obernkirchen Schaumburg Prussia	41 kg	7.12

	Found	Time of Fall unknown				
17.	1863 Feb 18	Russel Gulch Co.	29 lbs 35 grms	7.72		
18.	1863	Dacotah Ind. Ter.	10 grms			
19.	1863	Aeriotopos Bear Creek Col. U. S.	10 kg	7.43 7.692		
20.	1863	Newton Co Ark.				
21.	1863	Copiapo Chili	1.246 kg			
22.	1863	Rockingham Co. N. C.	11 lbs	7.78	86° 20'	79° 45'
23.	1864	Dorf Gross - Cotta S of Pirna	1/2 kg			
24.	1864	Kremnitz				
25.	1864	S. E. Missouri	4 grms			
26.	1864	Unknown from Wobler's Collection				
27.	1865	Bubnowly Goruckpfer India	250 grms			
28.	1865	Dolores Hidalgo E of Poblacion Mexico				
29.	1865	Tamentil in Quat Africa				
30.	1865	Charcas San Luis Potosi Mexico	780 kg	7.71		
31.	1865	Bonanza Coahuilla Mexico 40 W of Santa Rosa	78	7.825	28°	101° 30'

Found.		Time of Fall unknown				
32.	1865	Sieria de Dresa San	2.105 kg	6.12		
		tiago Chili		6.24		
33.	1865	Chili locality unknown	280 kg	7.66		
34.	1865	Meno				
35.	1866	Niakornak Greenland				
36.	1866	Mexico	3.6 gm	7.72		
37.	1866	Franklin Co Ky	24 lbs	7.692	38° 14'	80° 40'
38.	1866	Chili Cordillere near	104 kg	7.697		
		Atacama				
39.	1866	Dellys Algiers	76 gm			
40.	1866	(Pocra karta) Surakarta	7.831	7.831		
		Brambanan Java	7.842	7.842		
41.	1866	Puncal Cordillere	118 gm			
		near Atacama				
42. ?	1866	Ben Baigh Mt. Ayrokhie	321 gm			
		Scotland				
43.	1867	San Francisco Mez-	7 kg	7.835		
		quital Durango Mexico				
44.	1868	Gopalpara Assam	143 gm			
		India				
45.	1868 Apr	Cherokee Ga. Losttown	6 ^{lbs} 10 oz	7.52		
46.	1868 Sep	Schmöllen Duchy of	1.2194 kg	7.06		
		altenburg		6.75		
				6.8		

Found		Time of Fall unknown				
47.	1868	Autumn Macon Co Ala.		8 lbs	7.05	
48.	1868	S. E. Mo		9 ^{oz}	7.015	
					7.112	
49.	1868	Wisconsin 4 pieces		94 lbs	7.82	40° 22' N 88° 8' W
50.	1868	Nov 27	Danville Ala	4½ lbs	3.398	34° 30' 87° W
51.	1868	Wisconsin near Zurich 7 pieces				
52.	1868	Niro Urochne - Udenek. E. Siberia				
53.	1869	Trenton Washington Co Wisc.		350 gm		
54.	1870	Augusta Co Va		115 gm		
55.	1870	Elmae W. Alacama Chili		51.42 kg		
56.	1870	Ovifak Godhavn Disco Greenland		875 gm		
57.	1872	Eldorado Cal		85 lb	7.8	
58.	1872	Hacienda Louisiana Concepcion		385 ^{lb} 33 ^{lb}		
59.	1872	San Gregaria				
60.	1873	Aug	Madison Co N. C.	21 ^{lb}	7.46	
61.	1874		Wacoua Mitchell Co Kansas	58 lb	3.58 ^{lb} 3.81	39° 20' 98° 10'

Found Time of Fall unknown

62. 1874

Pittsburg Pa

7.741

63. 1875

Bates Co Mo

90 lbs 7.72 38° 20' 94° 22'

Unknown 1875

Yan Huit-

421 kg 7.824

law De que Yucunino

7.829

Mt- Dep., Oajaca

7.802

Mexico

65 Unknown

Rincon de Caparaso

1/2 kg

near Chilpancingo on the
road to Acapulco in

Mexico

The Litreature of Meteors

Lichtniet; Pharus, sive de Prodigis signis
causis libus ut vulgo vocantur, ex omni aere
collectis. Giessen # 1721

Bertholon. de l'Electricité des Méteors
2 B Paris 1787

Deutsche Uebersetzung: Die Electrici-
tät der Lufterscheinungen Lignitz 1792
Chladni über den Ursprung des von Pado
gefundenen und anderen ihr ähnlichen
Eisenmassen, und einige damit in Ver-
bindung stehende Naturscheinungen
Leipzig 1794

E. King, Remarks, concerning stones
said to have fallen from the clouds

from Philos. Transac. London 1766

Bonzenberg und Brandes. Versuch die Luft-
reinigung, Beschaffenheit und die Lage der Luft-
massen zu bestimmen Hamburg 1806

Esprit Des hommes. L'homme. L'homme
 L'homme. L'homme. L'homme. L'homme.
 L'Etat actuel de la science sur le phénomène
 des pierres de foudre. plus des pierres, plus
 tombées du ciel etc. plusieurs observations inédites
 communiquées par M. M. Pictet, Sage, Dardet et
 Sauquetin avec un essai de théorie sur la
 formation de ces pierres. Paris 1803

Güssmann, über Stürmer. Vienna 1803
 V. Racknitz, über die aus der Luft auf die Erde
 herabgefallenen Steine. Dresden 1804
 V. Ende, über Massen und Steine, die aus
 dem Himmel auf die Erde gefallen sind

Braunschweig 1804

Tringa. Ides sur le phénomène de
 l'éclair. Göttingen 1804

Folger, kurze Darstellung der Geschichte über
 das Vorkommen des gediegenen Eisens, so
 wohl des mineralischen als auch des problem-
 atisch-metallischen und anderer darauf
 Bezug habender Resultate. Dresden 1804

Trappung, Gedanken über die Luftsteine.

A. d. Franz. übers. von einem Freunde
Nissalienhändler. Göttingen 1805

Diruf. Ideen zur Naturerklärung der Meteor
oder - Luftsteine Göttingen 1805

Münter, die von Himmel gefallenen Steine
Kopenhagen und Leipzig 1805

Stokowitsch, „o wyświeszczenie kamienich
i ich brzoischochdenii“, d. i. über die aus
der Luft gefallenen Steine (u. d. L. Luftsteine)
und deren Ursprung. Charkow. 20 S. 1807
Duftschmidt, über einige Vorurtheile des
gemeinen Mannes und der Gelehrten

Linz 1809

v. Dallera, über Meteorcullyes der Alten vor-
züglich in Bezug auf Steine, die vom Himmel
gefallen.

Heidelberg 1811

Malch. Meteorsteine oder Aerolithen.

Schleusingen 1812

Maréchal, mon opinion sur la formation
des Aerolithes.

Paris 1812

Rivet les Morques. Monnaie historique et
musique sur les chutes des pierres tombées sur
la surface de la terre à diverses époques (Celtiques 1812
Joh- Outzen - Rime, de andole et origine
Ficolithorum. Olthimias 1876

Léman. Considérations sur les pierres, les masses de fer et les poussières dites météoriques (Sep. Abdr. aus Nouv. Dict. d'Hist. nat.) Paris 1785
v. Schreibers. Beiträge zur Geschichte und Kenntniss meteorischer Stein- und Metallmassen. Mit 10 Tafeln Wien 1820
J. Weber, von den Meteorsteinen und ihrem Entstehen. Landshut 1820

Krater. Versuch einer Entwicklung der
Grundbegriffe, die Metasteine, und Darstellung
der vorzüglichsten Hypothesen, ihren Ursprung
betr.
Wien 1825

Przewinski. O kamunisch Meteorogemischen 1833
~~Brax~~ Schnabel. de globis et meteorolithis commen-
 tarii. Marburg 1833

Philippos Joannis. Untersuchungen von Luftstein-
und Staubniederfällen und damit verwandten

Meteoriten

München 1836.

P. Partsch. die Meteoriten oder vom Himmel
gefallenen Stein und Eisenmassen im k. k.
Hof-Mineralienkabinette zu Wien. Wien. 1846.

Ronconi delle Aeroliti Discorso inaugurale
Padova. 1844.

Brown. P. A. An Essay on solid Meteors and
Aerolites Philad. 1844.

Baumhauer. Dissertatio de ortu lapidum
meteoricum. Traj. ad. Rhod. 1844.

G. M. Aeroliti quali comete abbiano esistuto in
terra, tesi diretta a chearisci sulla vera origine
degli aeroliti e sul modo con cui la terra
potrebbe trasformarsi in un bolide. 1. ed. Milano. 1844.

Shepard. Report on American Meteorites
New Haven 1848. (Gött. Gel. Anz. 1852. 313. Jb. N. A. 1852.
H. 5. Qu. H. 5. 470, 472, 6. 99. 327)

Shepard. Account of three new American
Meteorites, with observations upon the geographi-
cal distribution of such bodies. Charleston 1850.

Boisse. Recherches sur l'histoire et la nature des
Aerolithes. Rodez. 1851.

Oluf. Dissertation on metallic meteorites.

Gottingen 1852

Balcells, Reag. Lithologia meteorica. Barcelona. 1854

Coulvier - Gravier. Catalogue des globes filantes

(solides) observées 1841 - 1853

Paris 1854

R.P. Greg. An Essay on Meteorites. Phil. M. 1855

C. Harris. The Chemical constitution and chronological arrangement of Meteorites. Gottingen 1857

Coulvier - Gravier. Recherches sur les météores et sur les lois qui les régissent

Taf. Paris 1859

O. Buchner, die Feuermeteore, insbesondere die Meteoriten historisch und naturwissenschaftlich betrachtet.

Giessen 1859

Kennigott, über Meteoriten. Zürich 1860

Kesselmeier, Ueber den Ursprung der

Meteorsteine. Frankf. a-M.

1866

II

A general chronology of the air weather, seasons etc

London. 2. vol. 1749

Abel Remusat. Mélanges Asiatiques Paris 1825

Blode. Tabelle über dieⁱⁿ den öffentlichen Museen zu St-Petersburg befindlichen Aerolithen und kurze Charakteristik derselben, sowie Angabe der hierüber vorhandenen

Nachrichten 4. Bull. Acad. St. Pétersbg T. 6. Nr. 1. 1848

Arago. Astronomie populaire 1857

Baden-Powell. Rep. Br. Ass. 1849, 1850. 1852

Rigot de Morogues Mémoire 23. 327

Biot Catalogue gen. d'étoiles filantes etc. en. chine.

Paris 1846

Biot. Mem. Ac. Sc. de l'Inst. nat. d. France. Paris 1848

Capocci. Periodicität der Aerolithen. Pogg. Ann. Ergb. p. 521

Chladni. v. Hoff. u. Boguslawski. G. A. 15. 307. 50

225, 56, 375. 68, 329. 75, 229. P. A. 2, 151. 6, 21, 161.

8, 45. 18, 174, 24, 221. 34, 339. Ergb. 4, 1, 353,

Chladni. Feuermeteor. 173

Clark. Diss. 1852. Diss. im Auszug Sill. Am. J. (2) 15. 7

v. Ende. Massen. u. Steine. 28

- Falconet. Sactyles. Mem. Ac. Inscr. 6. 514
 Lincelius. Wunderzeichen, Nürnberg. 1557
 Greg. Essay. 33. Phil. M. (4) 8. 455. Inst. 1854., 398
 Haidinger, Wiener, Meteoriten. W.A.B. 1860
 Harris. Diss. 1859
 Harn. Lithologie. Pfaff. u. Friedländer Entdeckungen. 873
 Teleuter, 803. St. 9. 144. Schw. J. 4. St. 1.
 Kämtz. Meteorologie. 3. 264
 L. Lycosthenes, Prodigiorum, ac ostentorum chronicon. Basel. 1557
 Parlsch 1843. S. 6. (2) 1. 148
 Piddington, I. As. Soc. Bengal. 13. 885
 Quetelet. N. Cat. 1841.
 Rammelsberg. Handb. d. Mineralchemie, Leipzig, 901. 1860
 v. Reichenbach. P. A. 107. 160. 168
 Ritter. P. A. 18. 621
 G. Rose. Berl. Acad. Ber. 1862. Aug. 7
 Schmurrer. Chron. d. Seuchen Lübz 1823.
 Senoner Atti. Soc. ital. d. Scienze nat. Milano. 3.
 Shepard. Report. 1848. Catalog. si. Sammlung. 1860. Rep. Sill. Am. J. (2)
 2) 377. 4. 74. 6. 402,
 Kesselmeyer. Uepr. d. Meteorsteine. p. 45. a. ff.

Natural History of Meteorites.

Agricola de ortu et causis subterr. lib. 5. 1548

Hartmann. Misc. Ac. Nat. Curios. Dec. 2. A. 7. 1688. App. p. 1.

Valisneri. ~~et~~ cent. 5. 6. p. 195. Bacheley. Mem. Ac. Paris 1769. Hist. p. 20

Hartsoeker. Conject. phys. Haag. 1707 — 1709

Silberschlag. Feuerkugel. p. III. § 116

Halley. Phil. Trans. 29. 163. Pringle. ~~et~~ 50. 63. Blagden ~~et~~ 1784

Howard. ~~et~~ 1802. P. 1. M. 7. 168. Greville. ~~et~~ 1803. 300

Tronburg. p. de Phys. 1772. Nov. King. Bibl. Brit. 1796. Ann.

chim. 30. Missid. Nr. 127. 128. an. I

J. T. Mayer Lehrb. phys. Astron. 134. Dictet. zitt. Brit. 1796

Buymontsch, Voigt. Mag. 4. 515. Nicholson p. Jul. - Sept. 1802

p. de Phys. Nov. 1802. Gilb. Ann. 13. 291. Hahn. N. Schr. Ges.

nat. forschende. Freunde. 2. 202. Wrede. ~~et~~ 4. 290.

Garn. Lithologie, 71. 99. 305. 318. 353. 408. Gilb. Ann. 15. 437

G. A. de Luc. Bibl. Brit. 17. Nr. 3. p. 809, 18. 19.

Deterville, p. de Phys. 55. Gilb. Ann. 55. 35.

G. A. de Luc, Abregé de princip et d. faits conc. la cosmologie, p. 97. 1803.

Cavallo. Elem of nat or exper philos. 4. 372.

Klaproth. Gehler N. Journ. d. Chem. 7. 14. 1. 18, 23, 29.
 Bournon. f. de Phys. 1803. Apr. 56, 294. Gilt Ann. 18. 260
 Soc. philom, an XI. p. 153. Laplace v. Jach, monatl. Corresp
 6. 277. Olbers ebd. 6, 148. Gilt Ann. 19, 370
 de Dree. f. de Phys 1808 Mai. 333, Juin 405. Gilt Ann
 18. 270, 294.

Brandes, Voigt-Magaz. 5. 156. Benzenb. Sternsch.
 Patrin f. de Phys. 1809. Mai. 68. 401. Gilt Ann. 33. 189
 Münter, k. Dansk. Vidensk. Selsk. Skrifter. 1803. 1804
 3. 119.

Rigot de Mor 175. 310. Vauquelin, Gilt Ann. 15. 419
 Chladni. Vaterl. Let.-Offnungen. 1808. Gilt Ann. 19. 257
 Reuss. Leht. Min. 3. 1, 476. Ann. Lit. u. Kunst. in d. ost. State. 1804
 Trotthaus. Gilt Ann. 67. 342. Reynolds. Sill. f. 7. 1819.
 Poisson. Soc. Philom an XI p. 180. F. Rose. Pogg Ann. 4. 173
 Mencke. Gehler. phys. Wrtb. 1837. Art. Motu. p. 2148
 v. Jach. Corresp. astron 1522 Nr 5. Kämtz Met 3. 252
 Bergelius. P.A. 33, 147 Benzenb. Elschu. 212, Sill. f. 37, 93
 Mädler Astron. Bef. 325. Haidinger. Berichte 3, 495.
 v. Hoff. P.A. 36. 177. Ramlsbg. ebd. 62, Baumhr. ebd. 66, 465
 Haidinger ebd. 68, 437. — Inst. 1847. 379
 Schafhäütl, Münch, gel. Anz. 24, 553

41496^①

MSS
1660 B
SCDIRB

Karr, C. P.
Meteorites
[ca. 1878]

SMITHSONIAN INSTITUTION LIBRARIES

3 9088 00733 0889